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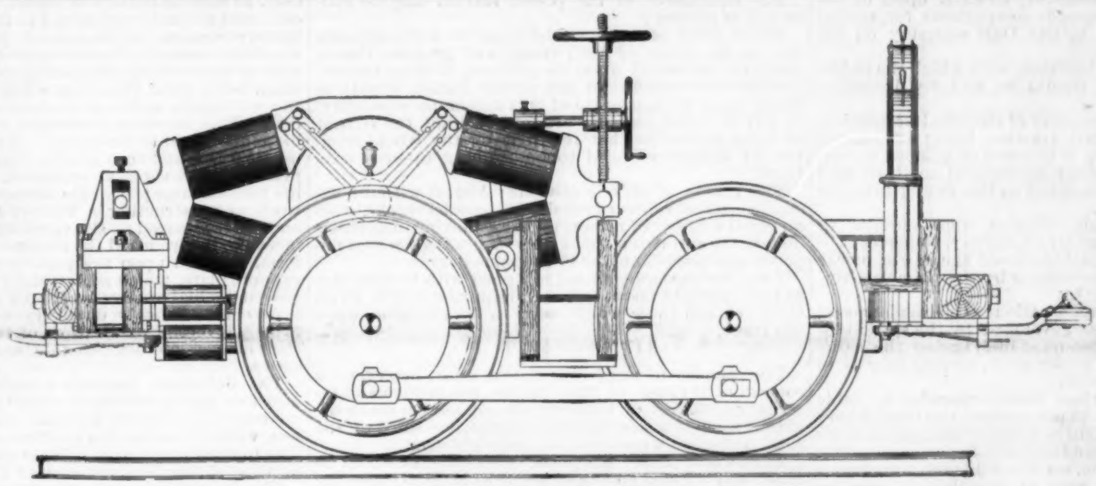
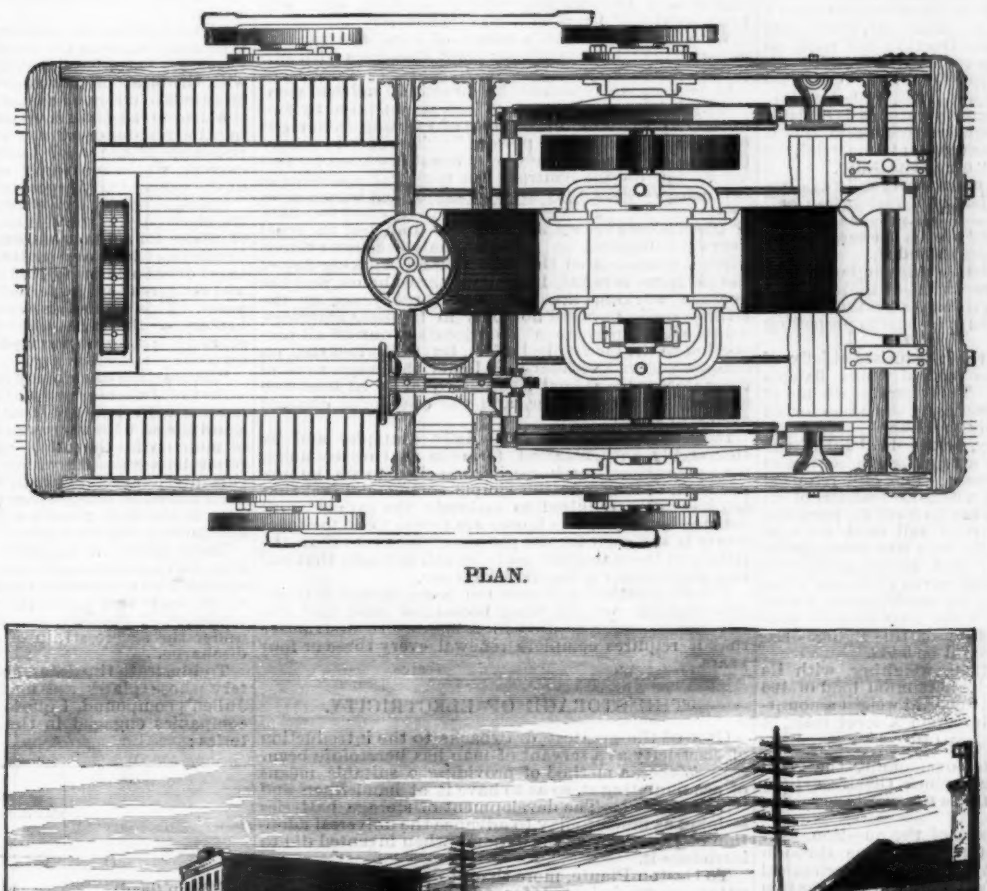
SUCCESSFUL TRIAL OF THE NEW DAFT ELECTRIC LOCOMOTIVE ON THE ELEVATED RAILWAY, NEW YORK.

WITHIN the last few weeks the Daft Electric Light Company have completed the enlargement of their electric locomotive, the Ben Franklin, and the motor has been put into operation upon the Ninth Avenue branch of the Manhattan Elevated Railway of this city, with great success. The locomotive draws the four-car trains with the utmost ease, and readily performs all the work now done by the steam locomotives.

The electro motor has now been running regularly, drawing trains between Fourteenth Street and Fiftieth Street for several days, and its complete success is generally admitted. We give herewith engravings, one of which illustrates the motor drawing a train; another is a side elevation, showing the operating parts of the machine with the cab removed; another is a plan view.



SIDE ELEVATION.



PLAN.

In these trials, primarily, the electrical machinery is entirely beneath the floor, and the starting gear on each platform requires less room for its operation than the ordinary handbrake. This disposition obviates all danger to the watches of passengers from magnetization. The balance of the car is not remotely affected.

In the Daft system the motor is absolutely independent of the body of the car, and is supported by a frame resting solely on the axles. This is insulated both electrically and acoustically by laminated India-rubber cushions which secure almost noiseless running, perfect freedom from jar and tremor or electrification of the metallic portions of the vehicle. The motor thus preserves an invariable position with respect to the axles, and its motion is conveyed to them by accurately fitted steel gearing, the only trustworthy method of transmission under the conditions of the case.

The qualities which it was necessary to demonstrate were: 1. Tractive capability. 2. Speed. 3. Mobility and handiness. And deliberate and exhaustive tests were applied, which have resulted in fully establishing the Franklin's excellence in these respects.

The tests for tractive capability were cumulative in their method and were abandoned only when the load drawn exceeded, by forty per cent., that which the loco-motor was guaranteed to pull, and up to this limit there was not the faintest intimation of overload or strain of any kind. On the contrary, everything indicated that it was working well within its ultimate capacity, and its prompt, responsive action in starting, acceleration, and stopping was a surprise to the most sanguine.

THE DAFT ELECTRIC LOCOMOTIVE BEN FRANKLIN, ON THE NINTH AVENUE ELEVATED RAILWAY, NEW YORK.

The greatest load it was committed to pull was four cars, which, with their seated load of 176 passengers and the loco-motor, amount to 77 tons. With four empty cars, making a train of 66 tons, it has maintained a speed of 25 miles per hour up and down the track for a long period, and with three cars in tow, or 53 tons in train, it has maintained, on two occasions, a speed of thirty miles per hour.

The load was increased, car by car, until eight were in train, aggregating with the motor 122 tons; and these it started, ran and stopped easily, promptly, and with every indication of being well within its ultimate capacity. Finally it ascended the maximum gradient in the route, 98 feet per mile, with the eight in tow, at a speed of 7½ miles per hour. This means a development of a little over 120 H. P.

The illustration shows the Franklin coupled to its eight-car train.

Another achievement with this train consisted in backing it from the main line to a siding, and necessarily around the reverse curve connecting them, upon a gradient of 53 feet per mile.

The trials for speed under load happened, on both occasions, in exceedingly stormy weather, and, in spite of it, results were obtained equaling and exceeding the schedule speed of steam locomotives at ordinary service. With the standard trains of four cars and a little over half of the possible seated load, a speed of 15¼ miles per hour was obtained, an excess of two miles per hour over the regular steam traction speed, and this without effort or resort to ample means still available for its increase.

The free speed trials might have been carried to a much higher degree than they were, as the power limit was not nearly approached; but various considerations rendered it advisable to confine them to the specified conditions, the chief of which was an earnest desire to have the test continue to the end—as it was from the beginning—unattended by the slightest accident or disappointment.

On the point of mobility and handiness, a short anecdote will exhibit fully its completeness. During preliminary trials, while handling a train of six empty cars—a total load of 94 tons—it became necessary to shunt the train on a siding to permit the motor to be in front on the return trip. The standard train on the Ninth Avenue line is composed of four cars, and the sidings are built of a corresponding length. In looking over the situation, before

shunting, it was discovered that the siding was only four feet longer than the train, and a great nicety of manipulation would be necessary to accomplish it, especially as the loco-motor was unprovided with means for working the air brakes, leaving the train entirely dependent upon hand brakes worked by only two men. The attempt was made, however, and, by skillful handling of the loco-motor, and zealous use of the ordinary brakes, the shunt was successfully accomplished, the train coming to a complete stop within the narrow limit of four feet.

The outcome of such a notable achievement as the foregoing ought not to be difficult of divination, and cannot fail to be revolutionary when its full import is appreciated. For it is indisputably demonstrable that it implies maintaining the existing service on the New York elevated railways at barely more than half the present cost.

This merit of electric propulsion is so generally admitted as to make it supererogatory to enter upon its demonstration here, and specific comparisons for, special cases will be furnished by the Daft company on application.

There is one contrast, however, with which the public is not so familiar as it should be, and its discussion follows:

The vastly superior economy of electrical propulsion, as compared with animal traction, being established beyond all peradventure, it becomes of interest to contrast the former with other mechanical methods and to ascertain their relative merit on this score; take, for example, cable traction.

The Daft system readily obtains, upon circuits of the length of the average street railway, 65 per cent.—in the shape of mechanical work—of the horse power applied to the dynamo generator by the prime mover, whatever its nature may be.

Careful experiments upon various cable roads reveal that of the total power developed by the stationary plant, the proportion consumed in dragging the cable along ranges from 65 to 85 per cent., leaving only 35 to 15 per cent. for useful work.

Averaging between these limits concedes to cable traction a utilization of 25 per cent. of the total power of its prime mover, which, in other words, expends its effort in 75 per cent. prejudicial and 25 per cent. useful work. The Daft system, on the contrary, apportions its effort thus: 65 per cent. to propulsion of cars, or useful work, and 35 per cent. to prejudicial work expended in the conversions of power from mechanical work into current and *vice versa*, besides overcoming the electrical resistance of the conductor and motors.

It is almost supererogatory to point out, since both electric propulsion and cable traction fall back on steam or some other motive power as origin, that this nearly diametrical difference in efficiency at once fixes for any special case the relative sizes, and therefore costs, of the respective stationary plants. It is difficult to credit the necessity of reiterating this lesson, but it is no less true in materialities than in immaterialities that one is only heard for his "much speaking."

The mechanical work done upon street railways has so rarely been made the subject of investigation and experiment that even those whose business makes such knowledge a frequent necessity are, in the majority of cases, completely at a loss where to find it.

To supply this lack, a few simple rules and examples are given herewith, which are sufficient to deduce all necessary quantities on which to base an estimate.

The principal resistances to be overcome in propelling a street car are two:

1. The rolling resistance, which consists chiefly of the friction of axle journals and of wheel flanges against the sides of the rails. This operates whenever the car is in motion, and is practically the same for all speeds that a street car is likely to make.

2. The resistance of gravity, or the dead lift of the load, which is only felt upon ascending gradients and is proportional to their steepness. The pull required to move a load upon wheels is a definite fraction of its total weight, and ranges from ten to forty lb. per gross ton, dependent upon the type of rail used, state of track, etc. D. K. Clark, C.E., who has perhaps experimented more extensively and systematically in this direction than any one else, gives 27 lb. per gross ton as the closest average of all the conditions of actual service, and the experience of the Daft electric railways has justified the adoption of this figure. Expressed as a percentage this would be 0·012.

A sixteen foot street car, then, weighing, with its motor, 6,200 lb., and carrying its maximum load of 100 passengers, weighing 14,000 lb., the total weight amounting to 20,200 lb., would require upon a level track a

$$20200 \times 0{\cdot}012 = 242{\cdot}4 \text{ lb.}$$

pull to keep it in motion, after overcoming the great resistance incurred in starting, which Clark's experiments show to be about four times the resistance when in motion.

This, however, is but one part of the question, as it is not pull alone, but the distance and time through and in which it operates that make up the mechanical work or horse power, and a few words in explanation may be necessary.

The unit of mechanical work is the foot pound, or one pound lifted one foot; or more generally, one pound resistance overcome through a distance of one foot. A force that accomplishes this is a foot pound, and one that exerts 33,000 of them for one minute is a horse power.

Suppose the car already referred to as moving at the rate of eight miles per hour, or, which would be the same thing, 704 feet per minute: the pull, as already seen, being 242·4, the power required from the motor would be

$$242{\cdot}4 \times 704 \div 33{,}000 = 5{\cdot}17 \text{ H. P.}$$

Whenever the car ascends a gradient, an additional resistance comes into play, which consists in lifting the entire weight vertically at a speed dependent upon the inclination. Suppose the same car upon a gradient of 220 feet per mile, or what is the same thing, one of a trifle over 4 per cent., and its speed reduced to four miles per hour, or 352 feet per minute.

For every 100 feet the car advances, it rises vertically 4 feet; or in one minute it rises $352 \times 0{\cdot}04 = 14{\cdot}6$, and the work done in effecting this is

$$20200 \times 14{\cdot}6 \div 33{,}000 = 8{\cdot}93 \text{ H. P.}$$

This amount added to the horse power required to overcome rolling resistance—2·59 H. P. at a speed of four miles per hour—will be the total required of the motors to keep the car in motion up the gradient, viz.:

$$2{\cdot}59 + 8{\cdot}93 = 11{\cdot}52 \text{ H. P.}$$

An approximate rule for ascertaining the horse power necessary to surmount a gradient is to multiply the total load by the percentum indicating the gradient, for the pounds, and deduce the feet from the speed of the car when ascending. The product of the two, divided by 33,000, will give the horse power necessary to overcome gravity, and this, added to the horse power required to overcome the level rolling resistance at the same speed, will fix the ultimate power of the motor. For example:

$$20200 \times 0{\cdot}04 \times 352 \div 33{,}000 + 2{\cdot}59 = 11{\cdot}19 \text{ H. P.}$$

The resistance encountered in rounding curves is also considerable, but the calculation of it is complicated and likely to vary with each case—so it is thought best to avoid generalizations which might only mislead.

The equipment of the power station may be estimated as follows:

While every motor must be equal to the maximum duty in the shape of load, speed, and gradient that it may ever be called upon to perform, it does not follow that the capacity of the power station should be based upon the aggregate of this maximum capability. It will be found perfectly prudent to limit the output of horse power to that required by the whole number of motors assumed to be running upon a level track.

The reason of this is obvious: Almost without exception, street railways consist of parallel tracks, with an equal number of motors on each, moving in opposite directions, and it is evident that a gradient which impedes one assists another in the same degree.

Take, for example, a road equipped with 10 such cars as those already instanced, each requiring 5·17 H. P. on the level, and there would need to be available, upon the track,

$$5{\cdot}17 \times 10 = 51{\cdot}7 \text{ H. P.}$$

The capacity of the power station must, however, be somewhat in excess of this, as the conductive and internal resistances of both circuit and motors make demands upon it amounting to perhaps one-third of the total output in a tramway of ordinary length.

This would imply a dynamo generator of about 75 H. P. and a steam engine of about 80 H. P. to meet the requirements of the case.

A short rule, easily memorized, is that: On a track whose gradients do not exceed 5 per cent., a steam engine and dynamo generator of 50 H. P. each will run a service of 5 cars without difficulty.

With an increase in number of cars, the relative magnitude of the stationary plant decreases with surprising rapidity.

It is frequently asked by practical railroad men, "Why is it that a car which can be operated by two horses requires a motor capable of exerting from eight to ten mechanical horse power?" The reply is simply that the car to which they refer is not operated by two horses, but on the contrary the horse car statistics in this country show that an average of ten horses is required per car. It is true that in most cases two only of these horses are employed at one time, but the cruel overwork imposed on these animals becomes evident when it is considered that the average working day of the car horse is reduced to about three hours, and the average working life to about three years, by the terrible strain imposed not only in frequent startings, which effect a permanent deterioration out of all proportion to the mechanical effort, but to the fact that on roads with even ordinary gradients the mean work of the unfortunate animal is often equal to at least two mechanical horse power, and the occasional demand even still greater.

It is easy to deduce from daily examples and by thoroughly authenticated formulæ that occasionally, for a short time, one horse is compelled to do the proper work of four, but the simple commercial fact that ten horses are required to maintain the rate of work for one day which two horses are forced to do for three hours is sufficient for the purpose, which is to show the fallacy of the statement made by railway men that but two horse power is required for a car.

For all practical purposes ten horse power is therefore required per car when horses are used, and this ten horse power is used in a manner so destructive that it requires complete renewal every three or four years.

THE STORAGE OF ELECTRICITY.

One of the greatest drawbacks to the introduction of electricity as a servant of man has heretofore been, says *Science*, a method of providing a suitable means of accumulating it, so as to have it at hand when and where wanted. The development of storage batteries is doing as much to-day to advance the universal adoption of electricity as the dynamo when invented did to introduce it.

To Gaston Plante, more than to any other investigator, are we indebted for our knowledge of storage batteries. He it was who first took advantage of secondary currents in voltaic batteries. He examined the entire problem of the polarization of electrodes, using all kinds of metals as electrodes or plates, and many different liquids as electrolytes: but he found that the greatest efficiency was produced by electrodes of lead in diluted sulphuric acid.

The first set of Plante cells was exhibited in 1860, before the Paris Academy of Sciences. It was immediately recognized that the storage battery had a field peculiarly its own, and that its application was only limited by the application of electricity. This was all before the introduction of the dynamo; and at that time little real commercial value was attached to the discovery, as the accumulators had to be charged by means of primary batteries, and it was then well known that electricity, when produced by chemical means, was far too expensive for any purpose outside of the laboratory.

Mr. Plante's discovery consisted of the fact that, if a current of electricity be passed back and forth through a pile composed as above, the plates of metallic lead become gradually converted into spongy lead on the negative pole, and peroxide of lead on the positive pole, and that such a cell would hold current and deliver it again with but small loss. The chief reason that a storage battery of this character could not be made of use practically was the fact that to form the lead plates it was necessary to pass the charging current daily back and forth by a series of reversals for many months before they became converted to their new forms.

On the discovery and perfecting of the mechanical production of electricity by means of the dynamo, the production of a suitable form of storage immediately became one of the leading questions of the day; but how this formation of Plante's plates might be hastened, so as to reduce the cost of manufacture within practical limits, was what was first to be solved. The first step forward was the artificial application of the oxides found on Plante's plates to sheets of lead which were bound on by strips of felt. After a short time, however, under the action of the sulphuric acid, these strips of felt became eaten, and the surface of the plates fell away.

It remained for Mr. Edmond Julien, a Belgian engineer, to make a battery of such a form as to be electrically and mechanically suited to the requirements. His battery consists of perforated plates or grids, into which are pressed the active materials or oxides, which, after a short charge, become almost one homogeneous mass, being what Plante, in a crude way, produced by the continuous action of a series of reversals of a current. This, however important, did not turn out to be his most valuable invention. When put to practical use, it was found that after a short time the positive plates showed signs of corrosion, which limited their life to about one year. He therefore entered upon the work of constructing a battery free from its defects, and, after a period of six years of continuous experimenting, he produced the Julien battery in its present form, founded upon the principle of an inoxidizable support plate, which is materially opposed to that employed by his predecessors. All support plates made before Mr. Julien's discovery were founded on the principle of the oxidization of the positive plates or their conversion into peroxide, so that they soon fell to pieces.

The difference between a lead plate and one composed of this inoxidizable alloy—lead, antimony, and mercury—is perfectly evident; one is practically useless, while the other can be successfully used for years. The importance of this point is made plain by a recent decision of the Commissioner of Patents.

The following is an extract from the report of Benton J. Hall, Commissioner, Dec. 8, 1888, in the case of an interference between John S. Sellon, assignor to the Electrical Accumulator Company, and Edmond Julien:

"The addition of mercury as a battery constituent is of great value in the formation of support plates of secondary batteries, on account of its tendency to unite with the other metal or metals of the plate, forming a more active union or contact between the plate which contains an admixture of mercury, and thus diminishing the resistance of the electrode, and therefore the resistance of the whole battery, thereby increasing the current, which is a result of the greatest importance in the use and application of secondary batteries.

"This property (that of diminishing the resistance of the electrodes) is so valuable, that, in the manufacture of plates for contact batteries, the addition of mercury to alloys of lead and antimony gives marked advantages over batteries formed of lead and antimony alone, and renders them preferred for secondary battery purposes. This is the characteristic value of the Julien battery, or the triple alloy battery of Julien, which is so much preferred in modern use on account of its durability and efficiency.

"The action of mercury in the three-element battery—that of Julien—should at once remove it from comparison with two-metal batteries of any kind as yet known, and which appears to be due to the admixture of mercury in the alloy, which renders it unlike the other batteries with which it is classified wrongly in this interference, and with which it should not have been placed in interference; for the presence of mercury in the plate gives it a distinct and separate place, and forms a different alloy."

These plates, in addition to being inoxidizable, and thus having practically an unlimited life, are of great rigidity and mechanical durability, which enables them to be made very much lighter, and also prevents any tendency of bending, or, as it is called, "buckling," under the severe strain of heavy rates of charge and discharge.

To illustrate the difference in weight between a battery whose plates are made of pure lead and of Mr. Julien's compound, I quote from pamphlets issued by companies engaged in the manufacture of these batteries:

	Weight of Cell in Pounds.	Capacity in Ampere Hours.	Capacity per Pound.
Gibson (lead)	120	200	1·6
Faure (lead).......	121	300	2·5
Julien (alloy).....	32	150	4·7

The value of Mr. Julien's inventions was immediately recognized by capitalists in America, which resulted in the organization of the Julien Electric Company, to exploit his systems of traction and lighting by means of these batteries. To that company is due the great progress which has been made within the last two years in the storage battery industry. American ingenuity and proclivity for labor-saving machinery has grappled with and overcome almost all the difficulties in the manufacture of these batteries, which, up to a short time ago, had been considered insurmountable.

The plates were at first cast, pasted, and pressed entirely by hand, and, in fact, these crude methods are still in use in Europe and by all other makers in this country; but the Julien Company have a machine capable of producing in one day one thousand completely finished plates. It is almost automatic in its action, and requires but one attendant. All the plates are uniform, and the action of the battery is therefore free from the irregularities inseparable from handmade batteries.

A word as to the application of storage batteries.

They have been extensively and successfully used for the following purposes: Electric lighting of buildings of every description; lighting of railway trains, street cars, and omnibuses; the traction of all vehicles, more especially of street cars; the propulsion of yachts, launches, and pleasure boats; the lighting of steam vessels, etc.; running motors of all kinds; telegraphy, signaling, etc.; medical uses; electroplating; general laboratory work, etc.

Electric lighting, however, is one of its most interesting and useful applications. It is here that its functions as a reservoir of energy become utilized to the greatest advantage.

When lights are supplied direct from a dynamo, the machinery must have a power capacity equal to the maximum number of lamps in a given installation; and, since the lights are usually only needed a few hours out of each twenty-four, the plant will remain idle the rest of the time. Moreover, to secure first-class results, the engine and dynamo must be of the best construction and design, steady and quick regulating, to prevent flickering. But with storage batteries the generator is not limited as to the time or manner of working, but can prepare its supply slowly, ahead of time, during the day, in the many hours at its disposal; and, in addition to its requiring a dynamo of very much smaller size, the machinery may be of much simpler and cheaper construction, as with the battery irregularities in movement can exist without in any way affecting the quality of the light, since the current given off from the accumulators is always uniform and regular, even while the charging current is subject to marked fluctuations. The storage battery is, in fact, an equalizer and regulator to the dynamo, besides acting as a reservoir in case of accident, which is liable to happen with the best machinery.

In all cases a direct lighting plant can be made complete and perfectly reliable by the addition of storage batteries, as the surplus energy, which can be stored while the dynamo is running under light load, can be utilized during the remaining hours of the day or night.

With water we cannot expect a reliable supply without providing suitable facilities for accumulating and storing certain quantities of it; and in every case we have such means of storage, whether it be a reservoir, tank, cistern, or well. With gas the supply must be yet more uncertain and unreliable without the gasometer, in which the product of the retorts can be stored ahead of the time of consumption. In the profitable and practical application of electricity we must also have a means of storing to insure an absolutely steady and uniform current, so necessary with incandescent lighting, and also to provide against any possibility of the extinguishing of the lights by failure of the generating plant.

Another great advantage to be obtained from the use of storage batteries is the great increase in the life of the lamps, due to the fact that the current flows with absolute steadiness at all times, thus adding from twenty-five to fifty per cent. to their life, and effecting a great saving, for the renewal of lamps is one of the chief items of expense in the maintenance of an installation.

They can, for example, be charged without trouble and danger from an arc as well as incandescent circuit. Thus the electric light may be introduced in many places where a special generating plant for charging batteries could not be employed, or where its expense would be objectionable. This permits of the introduction of incandescent lighting without too great initial cost of installation, or in the subsequent running expense.

In places where an arc circuit is already installed, the introduction of the incandescent light becomes a comparatively simple and inexpensive matter. The arc dynamo can be used in the daytime to charge the batteries, and at night to supply the arc lamps, while the stored electrical energy is used to supply incandescent lamps.

What one generation looks upon as a luxury the next regards as a necessity. Of the numerous applications of the inventions utilized during the present century for the promotion and extension of the comforts and luxuries of life, there has been, perhaps, nothing more wonderful than the improvements in the methods of obtaining and utilizing light.

As lately as fifty years ago the candle was the chief illuminant in use. This was replaced by the oil lamp, which was undoubtedly a great step in the way of progress. A little later this luxury made way for gas-light. But progress could not stop here. Having been educated to a proper appreciation of good light, the public, not satisfied with this improvement, demands that gas, in turn, shall make room for some other agent. The electric light has proved itself the only agency for the accomplishment of the difficulty of still further improvement.

Among its manifold advantages are:

The great superiority and steadiness of the light.

It does not overheat the atmosphere, nor charge it with poisonous gases, while depriving the air of its life-sustaining element, oxygen.

It also removes all danger to life and health caused by the escape of gas.

Ventilation, a matter of such vital importance to health and life, thus becomes a comparatively simple matter, the difficulties in this direction no longer increasing in inverse ratio to the amount of light used, as with gas.

The safety it offers over every other form of light, removing the ever-present danger of fire, by doing away entirely with the use of the match. By simply touching a button or turning a switch, any designated light or all the lights in a house can be lit from any part of the building. They also admit of a much more advantageous distribution of light.

The cost of insurance where electric light is used is in all cases reduced.

Its freedom from smoke and deleterious gases, which work such incalculable destruction to ceilings, walls, decorations, books, paintings, etc., makes its adoption the greatest possible saving. But, great as has been its success, its introduction into general use has been limited, as it has not been placed within the reach of all. It has been shut out from the very place where good light is most needed and appreciated, "at home," owing entirely to the method of producing it—that of lighting direct from a dynamo.

The electric lighting of houses distant from a central lighting station has heretofore, to a certain extent, been an impossibility, owing chiefly to the fact that a steam plant has been necessary, and that in the production of electric light direct from a dynamo it has been impossible to obtain light except when the dynamo is running.

The operation of a steam engine necessitates the presence of an experienced engineer, which immediately makes its production so expensive as to be beyond the reach of any but the more wealthy.

The time when light is most required in a private house is between the hours of six and ten or twelve o'clock at night, when it is almost impossible to obtain the services of a competent engineer.

The noises and vibrations attending the operation of a steam engine have been another drawback to its introduction, for few are willing to have machinery in operation in a private house until after the hour of midnight, or during the time when light is required.

There has been no means of producing electric light with the direct lighting method, so that light may be available at all times, except by the running of a dynamo continuously, and, unless light can be available at all times, it fails to compete with gas.

The storage battery, however, seems to overcome all these difficulties, and to solve the problem of incandescent lighting in isolated cases.

In the course of some remarks recently made before an electric light association by a prominent New York electrical engineer, the importance of storage batteries in electric lighting was very clearly shown in the following: "I would call the attention of the members, for instance, to the lighting of private residences which are detached, country residences, summer residences, and large mansions. I believe that here the storage battery has a sphere which it will hold as its own, for the reason that the direct system of lighting of to-day does not afford all the requisites of a perfect application of electricity for lighting. It has not supplanted gas, and you will find that wherever isolated plants are in use to-day, they still have gas. Now, I do not consider that we can look upon isolated lighting as a success until we see it drive gas out altogether. To do that, we must have electricity 'on tap' for twenty-four hours a day, the same as gas, and I can conceive of no system by which this can be done successfully except one involving the use of storage batteries as an accessory, if nothing more."

A storage battery can be charged with the use of almost any form of power during the hours of the day, and in many instances energy now running to waste may be utilized in laying up a supply for night use.

One of the interesting developments in this connection is the prominence of the gas engine as a producer of electric light. This power seems to be particularly fitted for work in connection with storage batteries. The operation of these engines is so simple that they can be cared for and run by the employes of almost any house. The power is always available. The gas in the engine is ignited by a spark from the battery, and, in fact, can be started by simply turning a battery switch, using the dynamo for a moment as a motor to bring the engine up to speed. Thus by the simple operating of a switch the entire plant is set in motion. The battery is charged during the day, and at night, when the engine is shut down, enough energy will have been stored to supply the house with light for the entire night.

One of the most interesting displays at the American Institute Fair, this season, was the installation of the Julien Electric Company, showing the application of storage batteries to the lighting of private residences in connection with a Baldwin gas engine and a United States dynamo. The plant consisted of a 4 horse power gas engine coupled to a 30 light dynamo and 36 cells of Julien battery. There were in the exhibit some 95 16 candle power lamps, in addition to two ⅛ horse power electric motors used for operating a fan and sewing machine—another application to family needs. The current from the battery can also be used for pumping water, the running of electric bells, burglar alarms, and other light work. The dynamo charges the battery during the day, and at night, when the full number of lights is turned on, the dynamo takes care of 30 lights, and the remaining 65 are taken from the accumulators. It will thus be seen that in addition to serving as a reservoir to be called on when the plant is not in operation, by the running of the dynamo, and at the same time discharging from the battery, a largely increased number of lamps is available, thus reducing very considerably the amount of power necessary to be introduced. It is generally acknowledged that light derived from storage batteries is of greater steadiness than that produced direct, thus increasing considerably the life of the lamps.

The cell employed was the type 19 C of the Julien Company, weighing complete about 44 pounds, which is rated by that company as having a capacity of 200 ampere hours, and the rate of discharge given is 30 amperes. It will be seen, however, that, as these lamps take about nine-tenths of an ampere each, the batteries were being discharged at about twice their normal rate, and, where occasion required, the engine was stopped and the batteries supplied current for the entire plant, thus discharging at almost three times their nominal rate.

This is a particularly creditable showing for these batteries. The principal difficulty heretofore in the use of accumulators has been that they have not been permitted to be discharged at a greater rate than from about one-tenth to one-eighth of their capacity, whereas in this exhibit they were regularly required to deliver their full capacity in about four hours.

The cells were in use from the commencement of the exhibition, October 1, until December 15, and did not in that time require the least attention on the part of the company, the plant being run entirely by a man in charge of the gas engines, who, until the opening of the fair, had never been in charge of an accumulator plant.

The lights were burned four hours each night, which, discharging at the rate of about 60 amperes, and occasionally at 80 to 85, made a total of 250 ampere hours taken out, while the rated capacity (discharging at the nominal rate) is but 200 ampere hours. This is an indication of the large amount of reserve energy there is always on hand in case of an accident or stoppage of the generating plant, or in case of an emergency.

AN ELECTRIC OMNIBUS.

IN the year 1881 the introduction of the Faure accumulator rendered possible the application of stored electrical energy to the purposes of tramway work, and the first electric car made was run by Mr. Radcliffe Ward on the Leytonstone line in 1882. M. Philippart, who had the introduction of the Faure battery on his hands, conceived the idea of applying it at once to tramcars, and arrangements were made with Mr. George Richardson, then chairman of the North Metropolitan Tramways Company, to experiment on the Leytonstone line. M. Philippart had this, the first electric car, constructed in Belgium and sent over to England, and the working of the car was in the hands of Mr. Radcliffe Ward. Numerous experiments were made, and some fundamental patents in variable-speed gearing, and details of the construction, which became evident on application in practice, were taken out by Mr. Ward. These experiments were only abandoned because of the unsatisfactory condition commercially of the only storage battery on the market. Some little time after, he started the construction of a car to run over the ordinary roads, but again, owing to the difficulty of obtaining good accumulators, this was dropped. In the early summer of 1887 he built an electric cab which was exhibited and run on the roads at Brighton, and it was about this time that Mr. Magnus Volk also built his electric dog cart, which was described in the illustrated papers, and there excited the attention of the Sultan of Turkey, for whom Mr. Volk has recently constructed a similar vehicle.

In the summer of 1888 the first electrical omnibus commenced to make runs over the London streets in the early morning hours. This omnibus is not of the type that will be used for running, for which purpose a model omnibus will be designed, and special cells ordered to fit this. In the present case the best storage cells obtainable for the purpose were used, and the omnibus built to carry these, and the vehicle is as appears in the illustration. Many experiments have been made with this omnibus on all sorts of roads, and under varying conditions, and Mr. Ward is now in the position of knowing experimentally exactly what tractive power is necessary for driving vehicles on ordinary roads—a matter of the utmost importance in the design and working of electric vehicles of this kind, and which has until now been more or less problematical.

From time to time we have had a note about the working of the electric omnibus, and have watched with interest its progress, knowing that such work is the inception of a vast development of the practical application of electricity to ordinary civilized life. It is therefore fitting that a representative of the *Electrical*

Engineer should have been the first to officially take a ride upon the electrical omnibus. Starting one morning last week, at 7 A.M., from a mews in Cromwell Road, South Kensington, we had an opportunity of judging the capabilities of the new car. It has the appearance of something between an ordinary closed bus without top seats and a parcels delivery van, of course without horses, and is capable of seating twelve persons comfortably. The driver sits or stands in front, with a switch and resistance frame, and handle with worm gearing to steer with, and a powerful foot brake. It is powerfully built to sustain the weight of accumulators, which slide in trays under the seats.

The cells are the new type E.P.S. traction cells, and were the first set of this type made by the Electrical Power Storage Company. The motors, of which there are two, are Gramme machines, built by Crompton & Co., Limited, which have proved to be thoroughly reliable and efficient. They are connected with steel chain gearing by Hans Renold, of Manchester, which are also thoroughly satisfactory. Mr. Ward has tried all the available methods—friction, chain, belts, and toothed wheels; they all have advantages for special conditions, but he finds the gearing he has adopted the best for these circumstances. The double-speed gearing alluded to has not been fitted to the first omnibus, but will be fitted for the cars to be used for ordinary work. The framework of the omnibus was constructed at the works of the Metropolitan Railway Carriage and Wagon Company, Limited, Saltley; the wheels are of special make to Mr. Ward's designs.

The car, which had been running the day before, started off easily and was run along Cromwell Road and Knightsbridge, turning into Hyde Park at the Albert Gate. The morning was bright and clear, and the ride was very pleasant. Not many people were about at this early hour, but the early tradesmen and workmen were, of course, moderately astonished at seeing the novelty. What it was, however, there could be no mistake about, for the lettering on the omnibus is large enough for all to read. Through Hyde Park was an easy and pleasant run; turning up by Hyde Park Corner the bus went on up the hill and out at the gate and along Upper Brook Street, across Bond Street into Regent Street, and thence into James Street, Haymarket. There is no doubt that the question of electrical road vehicles has been well tackled and its possibility demonstrated, and the application to ordinary work for many purposes is evidently only a matter of time.

The speed of the car is about six to seven miles an hour, about the same speed as that of an ordinary bus; a run has been made without stopping, for instance, from Notting Hill to Golden Square—a distance of 3½ miles—in 30 minutes. The running of the car has not been attempted among the ordinary traffic in the daytime at present, but there would be no great difficulty about this, especially for heavy and slow-moving wagons—such as railway delivery vans, dust carts, etc.; and with proper means of thorough control these would admit of taking their place in a crowded string of vehicles in the thickest London streets. The question of the slip of wheels has been freely tested, the cars having been run successfully on the slippiest days. This is mostly a matter of sanding the road, and a sand tube can be easily arranged in front of the wheels. At the same time, there are in this case no horses to slip down. Another point is the saving in dust from the droppings; the wear and tear will also be less, for this is greatly due to the pounding of the horses' feet like eight sledge hammers on the pavement.

The adoption of electric vehicles commercially is, of course, largely a question of cost.

The power necessary to drive such vehicles has now been ascertained, and the cost per mile for various vehicles calculated, and Mr. Radcliffe Ward claims that the result, all under guarantee from responsible manufacturers, shows a very considerable saving over the cost of horse vans. There is little doubt, if this means of traction proves successful in practical work, that the employment in towns, and in connection with railway collecting and traveling generally, the introduction of large numbers of electric vehicles would give an immense impetus to the electric industry.—*Electrical Engineer.*

ELECTRIC TREE FELLING MACHINE.

HITHERTO the only mechanical appliance to supersede hand labor in the felling of trees has been the steam tree feller, but the employment of steam for such a purpose is coupled with considerable difficulties. Not only is it necessary to place the boiler in close proximity to the tree that is to be felled, but the weight of the machine itself is considerable, and its application when the ground is uneven inconvenient. In a dense forest machinery of this description can only be used when the tree to be felled is either on the borders of the forest or is in a clearance accessible by a road over which the boiler can be transported. These difficulties are greatly minimized, if not entirely overcome, by the application of electricity. The source of power in this case is not a boiler, which must be placed near to the tree, but some prime mover and dynamo machine, which may be erected at any reasonable distance from the scene of operations; all that is required to convey the power being a pair of insulated cables, which can be easily brought into the innermost parts of the forest. The felling machine itself is lighter and smaller than a corresponding steam saw, and can therefore be taken over difficult ground and through narrow places where the former could not pass.

We illustrate, in plan and elevation, an electric tree felling machine which has been brought out by Messrs. Ganz & Co., of Budapest, especially for use in the Galician forests. The separation of the tree from the stump is in this case not effected by a saw, as is usual, but by a special drill. According to the nature of the wood, this drill may be used either to perforate the base of the tree with a series of holes, placed so close together that when the operation is completed all the fibers have been cut through, or it may be used to take a sweeping cut, in which case the tool is shaped somewhat in the fashion of a twist drill, but with prominent cutting edges along its side. The latter method is adopted for medium hard and for soft woods, and is illustrated in our diagram. The electromotor, E, with its platform, P, is placed on a light two-wheel carriage, which is taken close up to the tree, and shackled to it by clamps and chains, the latter being attached to the axles of the carriage in such a way as to be readily detachable, so that the carriage may be quickly withdrawn if there should be danger of the tree falling before the operation is completed. The platform of the motor is mounted upon a vertical spindle, D, in such a way that it can swivel in a horizontal plane. The drill, B, is carried in a spindle, which receives motion from the motor by means of belt gear, the spindle being provided with a long key bed, and the pulley with a fast feather, so that the spindle may be shifted forward or backward by means of the rack, R.

The mode of operation is as follows: After the machine has been brought up to the tree and shackled to it, the current is switched on, and a sweeping cut of suitable depth is taken across the surface of the tree by slowly rotating the motor on its vertical spindle. The drill is then advanced by a few inches, and a second cut is taken in the same manner, until about half the thickness of the tree has been separated from the stump. When this point is reached, clamps are driven in to keep the cut from closing up by the weight of the tree, and the operation is continued until a point is reached when it would not be safe to cut away more of the wood. The shackling chains are then loosened and the carriage is withdrawn to a safe distance, after which the final separation of the tree from the stump is performed by a hand saw or by the ax.—*Industries.*

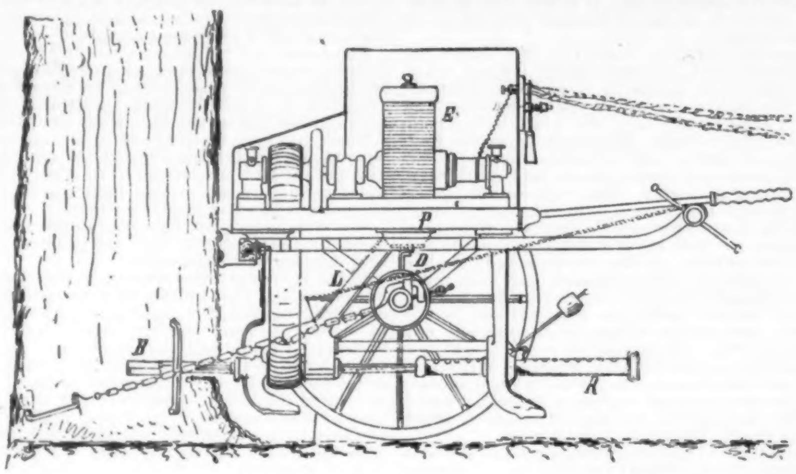


Fig. 1.

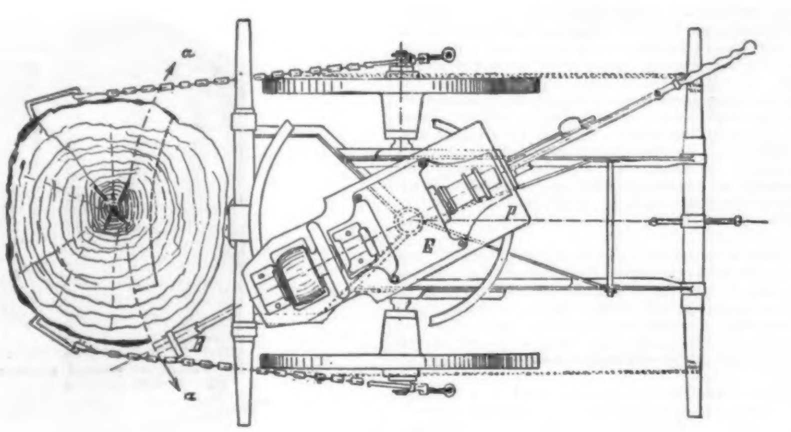


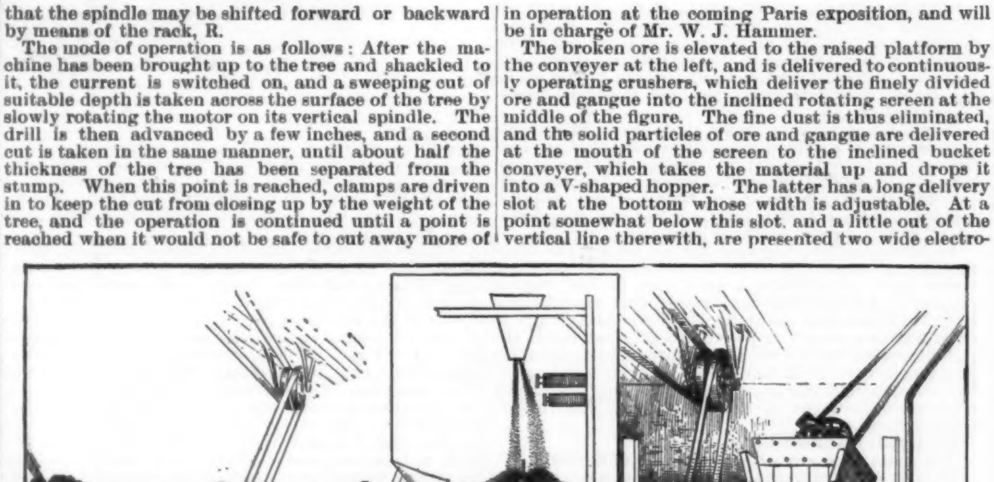
Fig. 2.

ELECTRIC TREE FELLING MACHINE.

EDISON'S MAGNETIC ORE SEPARATOR.

THE accompanying cut illustrates Mr. Edison's completed apparatus for concentrating and separating magnetic ores, in the form in which it will be shown in operation at the coming Paris exposition, and will be in charge of Mr. W. J. Hammer.

The broken ore is elevated to the raised platform by the conveyer at the left, and is delivered to continuously operating crushers, which deliver the finely divided ore and gangue into the inclined rotating screen at the middle of the figure. The fine dust is thus eliminated, and the solid particles of ore and gangue are delivered at the mouth of the screen to the inclined bucket conveyer, which takes the material up and drops it into a V-shaped hopper. The latter has a long delivery slot at the bottom whose width is adjustable. At a point somewhat below this slot, and a little out of the vertical line therewith, are presented two wide electro-



THE EDISON MAGNETIC ORE SEPARATOR.

magnets, both adjustable. These are energized by current from a small dynamo, and as the wide, flat stream of mingled ore and gangue falls from the hopper, the magnetic particles are deflected toward the magnets sufficiently to cause them to fall in a separate stream, while the unattracted material containing no iron falls straight down. On the floor of the pit beneath, a partition plate is set at a position such as to stand between the two streams, and permit of the heaps being removed without the possibility of getting mixed. The second magnet acts to prolong the pull on the falling magnetic particles, and thus insures more certain and complete separation from the gangue, and also causes the two streams to fall farther apart.

The whole process is continuous, and the conveyers render it automatic. Large quantities of ore can be separated at very little cost for labor, and the result is a remarkably pure ore ready for the smelting or blast furnace, or for use as fettling in puddling furnaces.—*Electrical Review.*

SIBLEY COLLEGE LECTURES.—1888-89.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

II.—THE GOVERNING PROPORTIONS OF STEAM BOILERS.

By CHAS. E. EMERY, Ph.D., of New York.

IT is proposed in this lecture to present and discuss curves derived from experiments showing the quantities of water which will be evaporated in a well designed steam boiler, under favorable conditions, when using different proportions of heating surface in relation to the work done; then to compare the results with those obtained in practice with boilers of different kinds and proportions, and from such comparison to deduce and discuss the laws relative to the economy of steam boilers as influenced by their governing proportions, independent of mechanical details.

In a steam boiler a high temperature is produced in the furnace by the combustion of the fuel, and ordinarily a portion of the heat is transmitted to the water by radiation to such surrounding portions of the heating surface as are exposed to the fire, and another portion by conduction and radiation from the heated products of combustion to the water-heating or, in other words, gas-cooling surfaces to which the gases are exposed on their way to the chimney. An important portion of the heat, however, passes away to waste on account of the high temperature ordinarily of the escaping gases and the quantity of surplus air which passes through therewith, carrying off, of course, the heat represented by its increased temperature. If the fuel were consumed in a non-conducting chamber of a refractory material, after the walls became heated to the temperature of the incandescent fuel, the gases would leave the furnace at its maximum temperature and the heat be utilized entirely by conduction and radiation to the heating surfaces beyond the furnace. The difference in the efficiency of heating surface exposed to direct radiation from the fire and of that exposed to direct contact with the heated gases, with such radiation as can take place from a gas, is not great when averaged with the results obtained with the entire heating surface of a boiler. The initial temperature of the furnace and incandescent gases is, however, so high that a very large proportion of the heat in the gases is absorbed by the first heating surface to which they are exposed either in the furnace or tubes. The temperature of the gases being thereby lowered, the succeeding surface receives less heat, the next succeeding surface still less, and so on, until the tubes at the end of a boiler have much less relative importance as evaporating surface. The decrease in the efficiency of surfaces at various distances from the fire has been approximately ascertained by calculations and by various experiments. Mr. Isherwood showed in his experiments on naval boilers that more than half the evaporation was performed by the heating surface in the furnace of the boiler, and it has been stated, to give an idea of the progression, that it may be considered roughly that half the heat is absorbed by the heating surface surrounding the furnace; that half of the remainder, or one-quarter of the whole, is absorbed in passing over the next equal area of heating surface; that one half the remainder, or one-eighth of the whole, is imparted to the next equal area, and so on. This progression is, however, too rapid for the actual conditions of practice. It is generally assumed that the quantity of heat passing from a heated stream of gas to a metal plate will meet with a certain resistance proportioned to the difference of temperature of the gas and plate, that again there will be a certain resistance to the passage of the heat through the metal plate itself, and, thirdly, a resistance to the passage of the heat from the plate to the water on the other side, but that the quantity of heat which will pass from the gas to the water will in each case be proportioned to the surface and the difference of temperature. This condition may be represented by the grinding away of the end of a prismatic piece of metal held upon a moving stone by its own weight. In Fig. 1, *a* represents such a prism with its end resting on a revolving stone, *d*. Evidently the pressure upon the base of the prism would be proportioned to the weight of the mass, and supposing, as would be approximately true, that the amount ground away would be proportioned to the motion of the stone and the weight per unit of surface, with the former constant, the latter would decrease progressively as the metal was removed. The reduction would then be represented by the triangle at the left, which is made of double altitude to represent the same area as the vertical projection of the prism. If the transfer of heat be considered exactly proportioned to the differences of temperature, the horizontal measurements of the triangle will relatively represent the amount of heat transferred at different periods, and the area of the same between the limits of temperature the total amount of heat transferred.

This result can be more tersely expressed mathematically. If T represents the original temperature, t the final temperature considered, H the total heat contained in the gases between the limits of temperature, and S the surface, we may express the rate of transmission as follows:

$$\frac{d\,\mathrm{H}}{ds} = \mathrm{A}\,(\mathrm{T}-t)$$

Since s increases as T−t decreases, or, what is the same thing, as t increases, we may put

$$s = \mathrm{B}\,t$$

$$ds = \mathrm{B}\,d\,t$$

Hence by substituting in this value of ds in terms of dt the first equation may be integrated, giving

$$\mathrm{H} = \frac{\mathrm{A\,B}}{2}(\mathrm{T}^2 - t^2)$$

which corresponds to the typical triangle *b*, Fig. 1, as A B shows the relation of the altitude to the base. It is known, however, that the transfer is much more rapid than shown by the horizontal ordinates or abscissa of a triangle, as can be illustrated by the curve *c*, shown at the right of Fig. 1. It has been considered

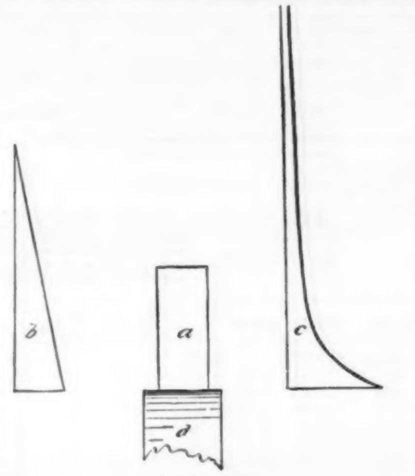


FIG. 1.

that the rate of conduction is more nearly represented by a curve of reciprocals or the hyperbola, and this form of curve has been developed apparently from the consideration simply that the rate of transfer is proportioned to the difference of temperature. The previous discussion appears to controvert such deduction, and the fact that the proportional quantities of heat transferred do practically increase at a higher power than the mere differences of temperature must be for the reason that such transfer is not made entirely by actual contact, but that a portion of the heat is radiated and has to a greater or less extent to overcome resistance indirectly, so that the transfers are more rapid than shown by an arithmetical progression. Such increase takes place whenever stored energy, as distinguished from constantly supplied energy, is required to overcome resistance. This principle applies to the transfer of heat in the present case when the resistance is to be overcome through distance, so that the loss of heat is not continually supplied from the source. The result of partial conduction and partial radiation would be to make the rate of transmission increase at a higher power than a direct proportion, and the quantities of heat transferred between the limits of temperature increase at a still higher power.

In examining the subject in connection with the trials of the boilers at the Centennial exhibition in 1876, the speaker considered that the theoretical discussion was at least insufficient, and appeared to show that after all the determination *a priori* of the ratio of decrease involved so many considerations dependent upon separate experimental investigations that it was as well at once to determine the desired relation directly from experiments, and he at that time made a collection of various tests on the subject, and plotted a curve therefrom which, with modifications, it is now proposed to present and discuss.

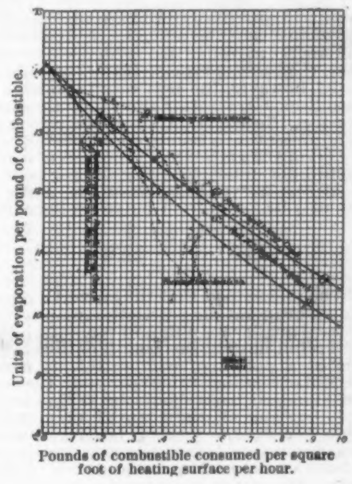
A large number of experiments with steam boilers had been described in various scientific journals and publications previous to that time, prominent among which were the experiments made for the English Admiralty, those for the U. S. Navy Department, those made at various national and local exhibitions, those made in 1859, 1862, and 1874 by the Societe Industrielle de Mulhouse, and elaborate experiments on locomotives made by Mr. D. K. Clark. The most valuable of all for the present purpose appeared to be those made during the years 1858 to 1866 for the United States Navy Department, under the direction mainly of Chief Engineer B. F. Isherwood, U. S. N., who was most of that time chief of the Naval Bureau of Steam Engineering.* Boilers of the water and fire tube types, constructed for naval steamers, were tried with great care, under all possible conditions as to rate of combustion, relative size of grate and area for draught, etc., and all the results were carefully tabulated for reference.

The experiments made previous to the year 1864 left so many questions to be settled as to the proper type and proportions of boilers for the naval service, that a commission of eminent civil engineers was appointed to conduct further investigations, under whose direction two marine boilers were constructed, one with vertical water tubes arranged above the furnace, the other with horizontal fire tubes in similar position, with which 177 experiments of 48 and 80 hours' duration were made, during the years 1865 and 1866, reports of which were printed and transmitted to the Navy Department. The experiments were all made by the same force, with similar fuel (anthracite), and great care was taken to secure uniformity in management, so as to determine accurately the true modification in result, due to the particular change of condition or proportion under trial.

The results of several of the series of experiments are plotted on the accompanying diagrams, Figs. 2 and 3, which, as indicated by the marginal notes, show the relation between the weights of combustible burned per square foot of heating surface and the units of evaporation (or weights of water evaporated at atmospheric pressure from a temperature of 212° F.) per pound of combustible.

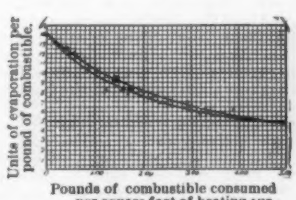
By the combustible it should be understood is meant the portion of the coal actually consumed in the fire, thus excluding the ashes and clinker. A pound of water evaporated at atmospheric pressure, from a temperature of 212° F., has, in relation to boiler experiments, become known as a unit of evaporation. Each pound evaporated under such conditions requires a certain definite quantity of heat, which has been found by experiment to equal 966·1 British thermal units.

The experiments best adapted for the determination of a curve were the naval experiments last above referred to, made with the vertical tubular boiler. This boiler was tested at different rates of combustion with a constant proportion of heating to grate surface, the results of which are shown by the connected points designated R in Fig. 2. The low results at the higher rates of combustion in this case are due to the fact that it was necessary to force the draught with either a jet or a blower. Other experiments were made, reducing the grate, using the maximum combustion possible with such reduced grate as shown in the plotted experiments designated U, and experiments were also made with reduced grates with a rate of combustion less than the maximum, as shown in experiments designated T. The most valuable series of all were, however, those in which the evaporative efficiencies for different proportions of heating surface were tested, first by stopping entirely the draught area through tubes and taking off the products of combustion to the chimney through openings in the back connection, the results of which are plotted at the right in Fig. 3; and, second, by successively removing transverse rows of tubes from the vertical tubular boiler, keeping the grate constant. The results for maximum combustion are represented by the dots connected by the broken line, Q, of the diagram, Fig. 2, and for reduced combustion by S on the same diagram. It will be seen that the general results of the several experiments, except those with forced combustion, are very well shown by the upper curve marked O on diagrams Figs. 2 and 3.



Pounds of combustible consumed per square foot of heating surface per hour.

FIG. 2.



Pounds of combustible consumed per square foot of heating surface per hour.

FIG. 3.

It is evident that, as the rate of combustion per unit of heating surface decreases, or, what is the same thing, as the heating surface per unit of combustible consumed is increased, the amount of heat absorbed will be increased until the highest evaporation theoretically possible is obtained.

Let c = number of pounds of combustible consumed per square foot of heating surface per hour, and E the number of units of evaporation per pound of combustible. Then the heating surface per pound of combustible consumed $= \frac{1}{c}$ which equals infinity when $c = 0$, and the total calorific value of one pound of combustible should, under absolutely theoretical conditions, be utilized when the heating surface to receive it is indefinitely large, or when $c = \infty$.

Although all anthracite coal contains more or less hydrogen, there is generally also some oxygen present, which will unite with the hydrogen in proportions to form water, leaving very little, if any, calorific value for the hydrogen; and even when there is a surplus of hydrogen, it appears to be combined in such a way that, except in rare instances, it does not appear to influence the calorific value of the fuel. The theoretical value of bituminous coal is also reduced in practice very greatly for similar reasons. It is therefore customary to consider the calorific value of the anthracite combustible equal to that of the carbon element, or 14,500 heat units equivalent to the evaporation of 15 pounds of water on the standard basis of units of evaporation above explained, but to obtain such a result would require absolutely perfect combustion in oxygen. Under practical conditions combustion must take place in air and an excess be supplied for dilution; and supposing this to be true also at the limit, and that the air for dilution equals that required for combustion, as is not infrequently the case, the evaporation per pound of combustible would be reduced by the amount of heat required to raise the temperature of about 24 pounds of air from say 72° to the temperature of evaporation, or

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* See "Isherwood's Engineering Precedents," vol. ii.; "Experimental Researches in Steam Engineering," vols. i. and ii.; and also Report of Commission Tests at the Brooklyn Navy Yard.

212°, a range of 140°, and the specific heat of air being 0·238, the calorific value of one pound of combustible is, for practical comparison, 14,500 − (24 × 140 × 0·238) = 13,700 heat units, equivalent to an evaporation of 14·2 pounds of water, which may be called the theoretical evaporation practicable at atmospheric pressure from a temperature of 212° (the standard basis).

In this way the length of the first ordinate of a curve is established in a satisfactory manner, and it is gratifying to find that a curve, from the point thus determined, accurately corresponds with the results of the experiments. A number of experiments plot above rather than below the curve, but such results may be due to the use of coal containing a little more hydrogen combined in a way that could be made available than the average specimens. The commencement of the curve could be located higher by considering a less excess of air or in including more hydrogen utilized, but as the experiments were made without testing the quality of the steam (though pains were taken to give large outlets so as to prevent entrainment), it is thought that the curve, as shown, represents the best results possible under average conditions. A free-hand curve was first drawn through corresponding points to ascertain the general shape and direction of a curve to represent the experimental results, and although, as must be expected in experimental work of this character, all the experiments would not actually conform to any regular curve, it was found that the results could be represented by a portion, O, of a right hyperbola, of which the equation is:

$$(1)\quad E=\frac{46\cdot045}{c+3\cdot016}-1\cdot067$$

in which c represents the weight of combustible consumed per square foot of heating surface per hour, and E the number of units of evaporation per pound of combustible.

The experiments made by the commission with the horizontal tubular boilers do not correspond as well with each other as those from the vertical tubular boiler. Plotted in connection with a large number from other boilers, the average results are lower than those shown by the curve, O, though some are higher. It seems probable that the difference is due to the customary differences in proportion, which will be referred to hereafter, than to the type of boiler. As ordinarily proportioned, however, the best results possible under average conditions are better shown by the curve, P, which intersects the curve, O, at points, c=0 and c=5, the latter representing a reduction of heating surface to double that of the grate when 10 pounds of combustible are burned per square foot of grate per hour. The ordinates of the curve, P, between the limits above mentioned, may be found from the following equation:

$$(2)\quad Ep=\frac{27\cdot287}{c+2\cdot04}+0\cdot824$$

It should be understood that the curve, O, represents the maximum evaporation practicable with anthracite coal of average quality for different rates of combustion per square foot of heating surface. For instance, when two-tenths of a pound of combustible is consumed per square foot of heating surface per hour, the evaporation on the standard basis should be 13·25 pounds, and with a combustion of eight-tenths of a pound of combustible per square foot of heating surface, or four times as much as before, the evaporation on the standard basis should be 11 pounds, or 0·83 of the previous result. The water evaporated per square foot of heating surface per hour in the two cases respectively would be 2·65 and 8·8 pounds, or as 1 to 3·32. Hence it appears that, within the limits mentioned, to effect a saving of one-sixth of the fuel the heating surface must be increased 3½ times, or, conversely, that, within the same limits, a given power may be obtained with a boiler containing less than one-third the heating surface of another by the use of one-fifth more fuel, and it may be stated in general that a large increase in power may be obtained with a comparatively moderate reduction of economy. The curve, O, shows with satisfactory accuracy what the relation should be, and furnishes ready means for explaining results with boilers which have been considered remarkable and even wonderful.

The conditions of each particular case must determine the question whether a saving of fuel, with increased first cost, is of greater importance than an original saving in cost of construction. For permanent works first cost can be increased till the saving equals the interest, for portable boilers reduction of weight is important, and for any case reasons will appear to determine the proper relation of the original and ultimate costs on the basis furnished by the curve, O, and equation (1), and manufacturers may be enabled to guarantee any possible result.

The development of a satisfactory relation between the power and economy of a boiler permits a modified expression for the efficiency. The efficiency, as ordinarily stated, may be termed the ultimate efficiency, and equals the actual evaporation reduced to standard basis divided by the evaporation due to the calorific value of the fuel, or 15 in this case. The maximum practical evaporation in any given boiler, with good proportions, depends upon the rate of combustion per unit of heating surface; so the performance of the same or different boilers burning different quantities of combustible per unit of heating surface can very profitably be compared on the basis of what we will call the "practical efficiency," depending upon the conditions, and equal to the observed evaporation reduced to standard basis, divided by the value of the ordinate of curve, O, due to the rate of combustion, or by the value of E in equation (1).

If F = the practical efficiency, e the observed evaporation, reduced to standard basis, and E, as before, the maximum evaporation by equation (1), for a given value of c, then $F=\frac{e}{E}$. For instance, when c = 0·4, E = 12·41, hence, if e = 10, F = 0·81 only.

The relations between the coal consumed per square foot of heating surface and the evaporation on the standard basis and per square foot of heating surface are shown in the following table, in connection with the corresponding "ultimate efficiencies" previously explained, and the amounts of fuel and quantities of heating surface required per horse power on the basis stated in the headings. The experiments appear to show that the water-heating surface only should be included in making the comparison. The explanation of this probably is that steam has lower specific heat than water, and that there is generally little provision for rapid circulation in the steam space of boilers. When the steam-heating surface is specially effective—for instance, when considerable superheating is obtained or when the boiler lifts water which is evaporated by the steam-heating surfaces—a portion of the latter should be included in applying the formula or referring to the table.

The table is based upon the highest possible evaporation for the several rates of combustion; so for boilers which have not had their proportions adapted to the peculiarities of their construction or cannot be operated under skillful management, a deduction of 10 to 15 per cent. should be allowed to secure certainty in the results, for which the performance of the boilers exhibited will be a safe guide:

1	2	3	4	5	6
c	E	cE	E÷15	34·52×1·2÷E	34·52÷cE
Combustible consumed per square foot of heating surface.	Water evaporated at atmospheric pressure from temperature of 212°.		Ultimate efficiency.	Coal (with 1-6 refuse) per horse power per hour.	Heating surface per horse power.
	Per pound of combustible.	Per square foot of heating surface.		On basis that one horse power requires 30 pounds of water per hour evaporated at 70 pounds pressure from temperature of 100°, or 34·52 pounds at atmospheric pressure from temperature of 212°.	
Pounds.	Pounds	Pounds		Pounds.	Square Feet.
Minimum.	14·20	....	0 95	...	....
0·1	13·71	1·37	0·91	3·02	25·18
0·2	13·25	2·65	0·88	3·13	13 03
0·3	12·82	3·85	0·85	3·23	8·98
0·4	12·41	4·96	0·83	3·34	6·95
0·5	12·03	6·02	0·80	3·44	5·74
0·6	11·68	7·01	0·78	3·55	4·92
0·7	11·32	7·92	0·75	3·66	4·36
0·8	11·00	8·80	0·73	3·77	3·92
0·9	10·69	9·62	0·71	3·87	3·59
1·0	10·39	10·39	0·69	3·99	3·32
1·5	9·13	13·70	0·61	4·54	2 52
2·0	8·11	16·22	0·54	5·11	2·13
2·5	7·28	18·20	0·49	5·69	1·90
3·0	6·57	19·71	0·44	6·30	1·75
3·5	6·00	21·00	0·40	6·90	1·64
4·0	5·50	22·00	0·37	7·53	1·57
4·5	5·06	22·77	0·34	8·19	1·52
5·0	4·68	23·40	0·31	8·85	1·48

In Fig. 4 the results of the trials of the boilers at the Centennial exhibition are presented in connection with the curves of maximum performance, O and P, previously developed.

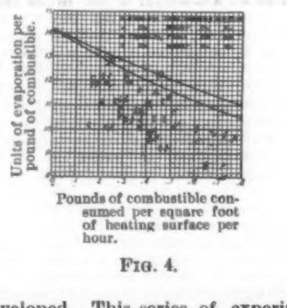


FIG. 4.

This series of experiments were made with the several boilers tested, one to determine the most economical performance at a rate of combustion supposed to be best suited to the proportions of the boiler, the other to determine what economy could be secured when the boilers were operated at full capacity. Each experiment for capacity is represented by a diamond in outline for experiments in which the combustion is determined in relation to the total heating surface, and by a black diamond for experiments referring only to the water-heating surface. For the economy tests outline and black circles refer similarly to the combustion per square foot of total and of water heating surface respectively. The capital letters refer to the several boilers tested and correspond with those on drawings of the boilers yet to be presented on the screen.

Most of the experiments, it will be seen, plot much below the curve, O, and it is important to ascertain the cause. The curves have been developed from actual experiments, varying the heating surfaces of the same boiler when operated under precisely the same conditions, and show the results due simply to a change in what may be called the proportions of the boiler, but really, as is evident from an investigation of the subject, such results are due more to a change in the quantity of fuel consumed per unit of heating surface, and the curves have been plotted on this basis. The authority for doing this is shown, first, by the results obtained, and second by combining the experiments with various kinds of boilers. In land-boilers it is customary to keep the rate of combustion per square foot of grade down to about eight pounds per hour, although it frequently rises to 10 and 12. In marine boilers this rate is increased to 12 and 16 pounds per square foot of grate per hour when anthracite coal is burned with natural draught and to 20 pounds and upward per hour for bituminous coal. In a locomotive, however, with forced draught, 75 and 100 pounds of coal are burned per square foot of grate. Apparently no losses result from such variations in the size of the grate, and, in fact, it appears indisputably that with a reduced grate and forced draught the air dilution is reduced and the evaporation therefore somewhat increased. It is reasonable to conclude, therefore, that when care is taken to insure perfect combustion by ordinary tests, the relative area of the grate upon which the coal is consumed does not affect the result, and economy depends under proper conditions upon the rate of combustion per unit of heating surface as stated. One of the principal reasons why all boilers do not show results agreeing with those plotted in the curve cannot be better stated than in the words of Prof. Rankine, who, in the "Steam Engine," page 261, states, doubtless from theoretical considerations only, that "the free circulation of the fluids which touch the sides of a solid plate is a necessary condition of the correctness of the formula for the conduction of heat through that plate, which has been given in article 219; and in each of these formulæ it is implied that the circulation of each of the fluids by currents and eddies is such as to prevent any considerable difference in temperature between the fluid particles in contact with one side of the solid plate and those at considerable distances from it." The importance of the free circulation of both fluids to secure maximum efficiency is evident, but the attention of writers and manufacturers has chiefly been directed to the circulation of the water, and the loss of efficiency due to the imperfect circulation of the heated gases along the heating surfaces has not been carefully examined. Imperfect circulation of water may cause overheating and danger, but, if the gases are not distributed properly over the heating surfaces, a greater proportion of the heat passes to the chimney, with loss, it is true, but without interfering with the regular duty of the boiler. From variations of density, particularly when steam bubbles are formed, a more or less perfect circulation of water will be caused in all locations not exceptionally bad; but as the heated gases are in rapid motion toward the chimney, there is little opportunity for the transfer of particles from the interior to the exterior of the various streams, and the heat of the interior portion can be only imperfectly transferred to the heating surfaces by radiation.

Moreover, in many boilers there are lines of least resistance, which the heated gases may take on the way to the chimney, that do not lie directly along the heating surfaces, and in other cases there is sufficient area to pass the gases along or between a portion of the heating surfaces in the most direct line to the chimney, so that sluggish currents only are maintained in other portions. The result is that some portions of the heating surfaces have a very low evaporative efficiency, which causes a low average result. For instance, if Fig. 5 represents one of a type of boilers in which a

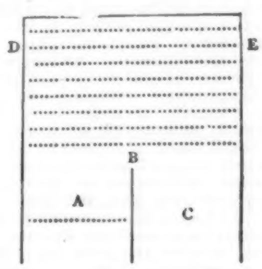


FIG. 5.

grate, A, is one side of a bridge wall, B, and a flue, C, connected to a chimney on the other side, and the dots represent heating surface upon vessels of any shape, it is evident that if the space over the bridge wall, B, be sufficient to pass the volume of the gases, a very small proportion will circulate in the chamber above; and, even if the bridge wall be continued upward by a partition between the heating surfaces, evidently the shorter route to the chimney will still be close along and over the top of the partition; and, at moderate rates of combustion, the circulation of gases near the ends, D and E, will be sluggish, and the heating surface there comparatively ineffective. The remedy suggests itself of decreasing the area between the heating surfaces so as to force a larger portion of the gases to take a more indirect route, and thereby raise the efficiency of heating surfaces more remote from the direct line to the chimney. Mr. Isherwood has discovered that by reducing the cross area for draught (or the calorimeter as he terms it) of a tubular boiler, the economy is increased; and he accounts for it partly by the reduced combustion and partly by the higher temperature in the furnace, due to "the less air dilution attending the less calorimeters."* The latter suggestion does not appear to be supported by later experiments. The general principle appears to be that by judiciously decreasing the area for draught so as to increase the resistance along the most direct lines to the chimney, the products of combustion are better distributed and circulated among and along the heating surfaces, and the average efficiency of the latter increased. It is true that the reduction is unnecessary when there is no well-defined short line to the chimney, as explained hereafter. So, also, some of Mr. Isherwood's experiments appear to contradict the principle. Referring to the experiments with a horizontal tubular boiler on the United States steamer Miami, those made at the highest rates of combustion plot very near the curve, O. In other experiments made with ferrules in the ends of the tubes, reducing the draught area, the results were no higher than before, although the combustion per unit of heating surface was decreased. The explanation is probably as follows: The ferrules increased the resistance so that the quantities of heated gases passing through the several tubes were nearly equalized, but the gases flowed along the top of each tube, and the bottom was not as effective as if the reduced area had been continued the whole length, for which other experiments show economical results.

The true condition of efficiency appears to be that the tubes or passages must be full of gas moving with nearly uniform velocity in all parts.

(*To be continued.*)

THE CHEMICAL STORM GLASS.—Dissolve in alcohol 2 parts camphor, 1 part nitrate of potash and 1 part sal ammoniac. Then add water drop by drop until the mixture begins to grow a little cloudy. The solution is then ready for introduction into the tube. Another formula is the following: Dissolve 2½ drachms camphor in 11 fluid drachms of alcohol. Dissolve 38 grains of nitrate of potash and 38 grains of sal ammoniac in 9 fluid drachms of water; mix the solutions.

* Isherwood's Experimental Researches in Steam Engineering, vol. ii., page xcv.

[Continued from SUPPLEMENT, No. 686, page 10966.]

THE NICARAGUA CANAL.*

By Commander H. C. TAYLOR, U. S. Navy.

CONCERNING the traffic which will use the canal, it may be divided into the following classes:

	Tons.
1. Trade across the Isthmus	1,217,685
2. Trade between Atlantic and Pacific ports of United States	145,713
3. Trade between Atlantic ports of United States and foreign countries west Cape Horn	752,585
4. Trade between Pacific ports of the United States and foreign countries east of Cape Horn	879,844
5. Trade around Cape Horn of European countries	1,471,399
6. Trade of British Columbia with Europe	39,818
Total tonnage	4,507,044

Our Pacific ports are now 13,000 and 14,000 miles away from us by way of Cape Horn. The distances by the canal will be 4,500 to 5,500 miles, and here again we shall gain a great stride upon Europe, and be nearer to San Francisco by 2,500 miles, instead of being that much further away, as we are now. The natural growth and development of these Pacific States and Territories will soon furnish thousands of tons of traffic for the canal, for the hundreds that exist under the present conditions. San Francisco owns more ships and a greater tonnage to-day than at any previous time. Portland, Ore., with 40,000 inhabitants, last year handled 12,500,000 pounds of wool and 1,500,000 pounds of hops. Her domestic exports amounted to $9,000,000 and her foreign exports to $5,000,000. Her merchants moved 238,000 tons of wheat and flour, and her grain fleet numbered seventy-three vessels, registering 93,320 tons. The total foreign and coastwise exports from the Puget Sound collection district, last year, amounted to nearly $9,000,000. The salmon canneries of the Northwest coast shipped 1,500,000 cases. The acreage and product of the wheat fields of eastern Oregon and eastern Washington have doubled within ten years, and there is enough vacant wheat lands to permit the same phenomenon within the next decade.

The lumber trade of Oregon and Washington presents the most notable development of any line of commerce during the past year. In 1886, the total shipment was 6,000,000 feet. In 1887, it averaged 4,000,000 feet per month, or eight times the total of 1886. There are said to be 20,000 square miles of yellow and red fir alone in Washington, generally known in trade as "Oregon pine," and the trees of these forests reach twelve feet in diameter and 300 feet in height. The timber field of Oregon is a quarter of the superficial area of the State, or 25,000 square miles. The wheat, lumber, fish, wool, furs, and other commodities of the Pacific Northwest will be provided to commerce in increasing quantities, and with greater profit to the producers, when cheap water transportation is at hand to convey them promptly to the world's markets.

The trade between Australasia and our Atlantic ports has quadrupled since 1865, though it is still trifling in comparison with the total foreign commerce of those colonies, but it has grown to what it is without encouragement, and in spite of obstacles and disadvantages, and slight favoring circumstances might open up for us large possibilities in our relations with young English-speaking peoples whose foreign commerce already exceeds $500,000,000 per year. The total tonnage entered and cleared at New Zealand ports in 1885, exclusive of coasters, was 1,032,700, of which a considerable part was by sail with Europe. The distance from Liverpool to Auckland is 500 miles less by Nicaragua than by any other route, and 2,524 miles less than by the Cape of Good Hope. It might very well happen that a part, at least, of this European trade with New Zealand will choose the Nicaragua route, not so much for the distance saved over Cape Horn as for the more favorable weather, winds, and currents to be met with in the latitude of the canal. Sailing vessels between Europe and Japan would, by way of Nicaragua, save at least 3,000 miles over other routes.

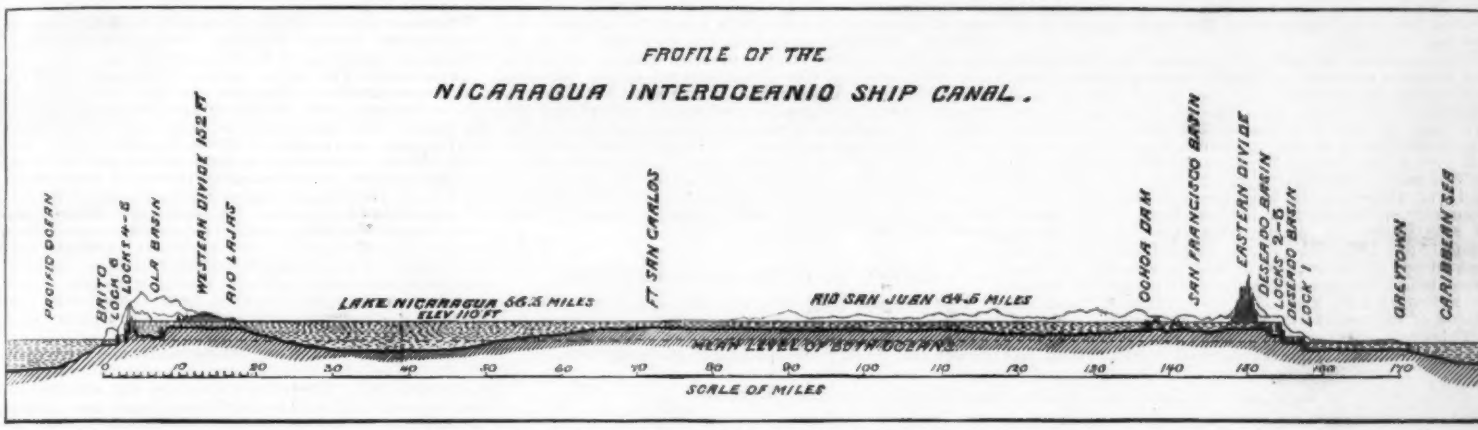
The stimulus which our domestic and near-by foreign commerce will receive from the safe and sure progress of an interoceanic canal toward completion, the natural increase, in six years, of all the classes of trade within the zone of attraction of the canal, and the fair probability of additions from the European traffic by sail with Japan, New Zealand, Fiji, and the South Pacific groups, should render it safe to predict a total tonnage of six to six and a half millions for the Nicaragua Canal in 1894. If the cost of constructing the canal should prove to be double the estimate of the engineers, the financial venture would still be safe and profitable. The commerce which exists to-day assures so much. Half of that commerce is our own. It is wonderful that it should have maintained itself so well in view of the disadvantages under which it has labored.

The greatest traffic of the Suez Canal in, 1885, was 8,985,411 tons, in 3,624 vessels. Its present charges are nine francs per ton. While the tonnage and consequently the receipts fell off slightly in the following years, the latest returns show recovery from this slight relapse, and it is safe to consider 9,000,000 as the present annual tonnage. It must be remembered that this canal opens in the Red Sea, which has always been impossible to sailing ships, on account of the calms. Situated as it is, the Nicaragua Canal route offers every facility for the passage to and departure from the termini of the canal of sailing vessels, for the trade winds are constant for ten months in the year, while for the other two a breeze blows in some direction, generally southwest, giving the vessels dependent on their sails a constant opportunity to keep themselves under control.

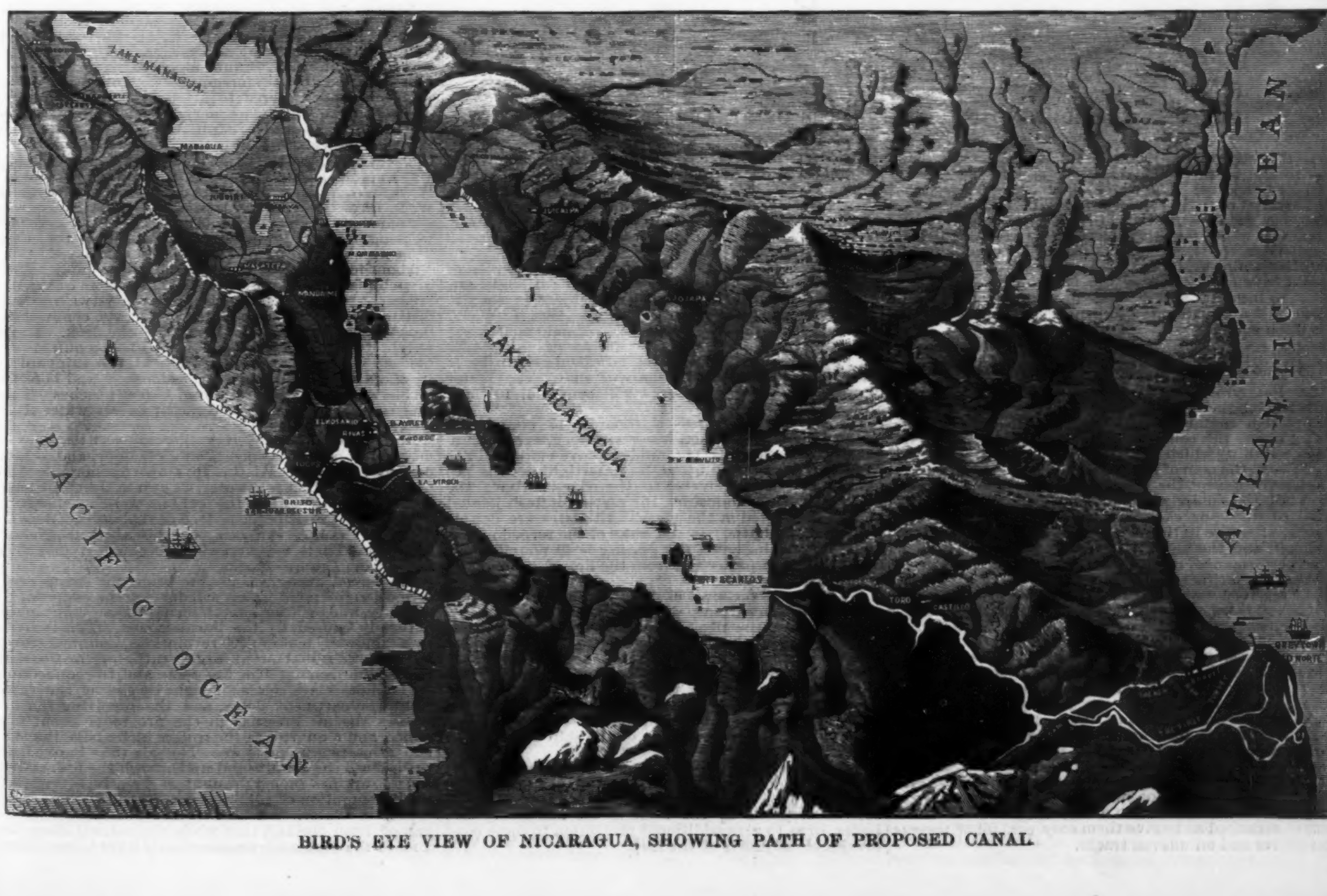
A large portion of the traffic on the Suez Canal is by tramp or freight steamers, to whom economy in coal is of the first importance. Hence, these vessels, though they may return by Suez, will be undoubtedly glad to avail themselves of the favoring trades from Europe to Nicaragua, and again from Nicaragua to the Indies or China and Japan and Australia.

It is safe, therefore, to conclude that a portion at least of the tonnage passing through Suez will find its way to Nicaragua.

Such, then, are the natural advantages and the general prospects of this enterprise. Let us see what the



PROFILE SHOWING LOCKS, DAMS, AND DEPTH OF CUTTINGS.



BIRD'S EYE VIEW OF NICARAGUA, SHOWING PATH OF PROPOSED CANAL.

* A paper recently read before the Franklin Institute. From the *Journal* of the Institute.

present company has done to avail itself of nature's favors.

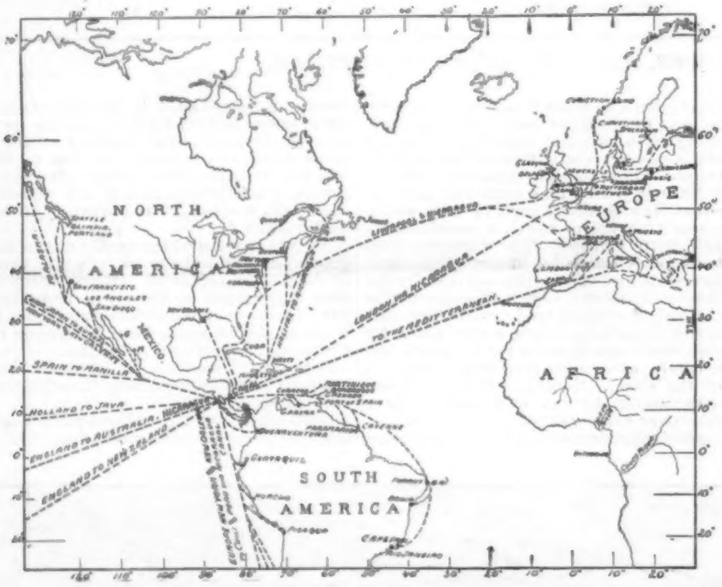
The company has obtained from Nicaragua and Costa Rica concessions of great value. These have been ratified after due consideration by the congresses of those republics. The concessions bestow all privileges for this canal, and a railroad and telegraph along its route, as well as land grants amounting to about a million and a quarter acres, most of which is on the canal line. The company has for nearly a year kept a force of 200 men at work in Nicaragua, who have completed the most elaborate and detailed surveys of the location, and have acquired the most intimate acquaintance with the work before it.

Borings along the line of the canal have now been continued for ten months, and the cube to be extracted is intimately known, both in kind and quantity. In addition to this, the company has presented the enterprise to the notice of engineers, business men, and capitalists of this country and Europe, in a thorough and impartial manner. It has blinked at nothing, has extenuated or concealed no defect or difficulty. The enterprise is now before the world, depending on its naked merits for approval. In carrying on these surveys and other works, the company has shown its sincerity by expending about $400,000, and this in addition to millions of dollars worth of work done by the United States government on the same ground in the last twenty years.

The canal can be built and equipped for $80,000,000, but we must organize the final company liberally, and not cramp the enterprise, if unforeseen wars or other complications should intervene to increase its cost. We must be ready to use $100,000,000, if necessary. The traffic ready to use the canal as soon as opened will give a net revenue of from $12,000,000 to $15,000,000 annually. The final work of the preliminary company is, therefore, to organize the Maritime Canal Company of Nicaragua and Costa Rica, with a capital of $100,000,000. A charter from the United States, though not indispensable, is undoubtedly beneficial, and an act of incorporation was introduced in Congress during the present session. It passed the Senate in February last, and will, it is believed, pass the House of Representatives in December next.

This great enterprise will have results far-reaching and permanent. The commercial world, which has been moving westward since the dawn of history, will be brought by this canal to Philadelphia, New York, and New Orleans. The whole circulation in the veins and arteries of trade will be reversed in its direction.

It is a great satisfaction to me to be the humble agent selected to lay this project before so distinguished a society as the Franklin Institute. I cannot doubt, had Benjamin Franklin lived in these days, that he would have been found in the forefront of this enterprise, so fraught as it is with profit to our own commerce and industries, and so beneficial to all the dwellers upon earth.



MAP SHOWING PROBABLE PATHS OF STEAMERS.

A NOISELESS AND SMOKELESS LOCOMOTIVE.

At Palmyra, Wis., about forty miles northwest of Milwaukee, there may be seen to-day a new, small locomotive engine (but large enough to draw several street cars), the construction of which is so different from anything which has preceded it as to be a genuine surprise to the man of science as well as to the practical engineer. Except the noise of its wheels moving upon iron rails, it is noiseless and smokeless. The fuel, any kind of wood or coal, is perfectly consumed. The steam, after use in the engines, is condensed in a new manner, and the water at the boiling point is reused. The performances of this remarkable piece of mechanism are so startling as, naturally, to cause a statement to be received with incredulity by those who have not witnessed them. To see and experiment with a locomotive which starts, stops, and reverses its direction of movement so silently and easily that, if your eyes are closed, you cannot detect the instant when the direction of motion is changed is a strange experience, and tells more plainly than words that the phenomenon before you may mark an era in the history of engines and motors. The objections to the ordinary locomotive which I have enumerated above are all overcome in the new engine. The rigid bases and all the shocks incident to a rough and uneven track are absent. All the wheels of the new locomotive are drive wheels and all its weight is traction weight. The necessity for a front guide truck does not exist, the drive wheels being so arranged as to give them easy control of the car on curves and on uneven tracks.

The most surprising feature of this locomotive is that there is very little waste of steam, heat, and water in operating it, as the steam is not thrown away after using, but the water of condensation is returned to a high pressure boiler and reused over and over again with but small loss of heat. The noise incident to a forced exhaust, common in the old system, is done away with here. The combustion of fuel is so complete that no smoke exists. The side motion and jarring felt in the ordinary engine is done away with, and stopping and starting and reversing the motion of the engine are very easily accomplished.

This engine runs equally well in either direction. One supply of water and fuel is sufficient for half a day's run or even a longer run. Nothing is wasted, which means an economy in operation never before approached in this class of machines. In answer to the claim made that it is very difficult, if not impossible, to pump boiling water, I can only say that this is easily done in this engine every day, as any investigator can see for himself.

I have purposely avoided going into details of a technical nature, my object being to state results only. The advantages of this new locomotive over the ordinary one are many and revolutionary in their importance. It need not be much more than half as heavy as the present ordinary locomotive engine, and the cost of operating it is so much less as to astonish engineers. Noiseless, smokeless, and cinderless, it can be used in the crowded streets of cities without objection and with none of the disadvantages of the common grip car. The inventor is Mr. T. T. Prosser, of Chicago, who is widely known as a mechanical expert and engineer. It seems to mark an era of great advance in the uses of steam, and nothing which the last half century has seen in this line has attracted the attention which will be directed to this new locomotive the moment its remarkable features are fully made known to the mechanical and industrial world.—*Duane Doty, in Railway Age.*

THE U. S. GUNBOAT YORKTOWN.

The gunboat Yorktown is the first of a group of three, all similar in design. She is somewhat smaller than the Swatara class of vessels, but in offensive and defensive power and speed is immeasurably their superior.

She is a twin-screw, coal-protected cruiser, with poop and forecastle decks, with an open gun deck between.

Forward and aft, throughout the length of the vessel, is a three-eighths inch steel watertight deck, under which are placed the machinery, magazines, and steering gear. The principal dimensions of the ship are as follows:

Length between perpendiculars, 226 ft.; depth of hold, 18 ft. 9 in.; draught forward, 13 ft.; draught aft, 15 ft.; mean draught, 14 ft.; displacement in tons to L. W. L. (loaded water line), 1,703 tons; area, L. W. L., 5,765 sq. ft.; sail area, 6,352 sq. ft.; indicated horse power, natural draught, 2,200; forced draught, 3,300 H. P. Her maximum speed is calculated to be 16 knots, but it is believed she will show even better figures than these. Her crew will consist of 160 men all told.

The Plating (outside).—Garboards, 15 pounds, or about ⅜ inch; from thence to main deck, except double strakes amidships, 14 pounds; above main deck, 10 pounds. The plating up to the watertight deck is lap jointed and single riveted at the edges. Above the watertight deck, amidships, the plating is flush jointed and single riveted at the edges. All plates are double riveted at the butts. In the wake of the torpedo ports and the machine guns the plating is 40 pounds, or 1 inch thick, as a protection from the fire of an enemy's machine guns.

A conning tower, oval in shape, is built on the forecastle deck, athwartship, 7½ × 4 ft. fore and aft, 5 ft. 4½ in. above the deck, with a cover with a vertical travel of 3 inches. The tower is fitted with complete steering apparatus, speaking tubes, and telegraphs to the engine room. A handsome wood pilot house is fitted forward of the conning tower, with plate glass windows, steam steering wheel, telegraphs, etc. This pilot house is to be used in time of peace when cruising; but in an action all manipulation of the ship will be from within the conning tower.

Her rig is that of a three-masted, fore and aft schooner. In coal endurance, the normal supply is 200 tons, but the bunker capacity is for 400 tons. This coal is disposed in the wake of the machinery and boiler, so as to give additional protection to these most invaluable adjuncts of the ship.

ENDURANCE OF THE YORKTOWN.

Speed.	Indicated horse power.	Coal.		Distance per day	Coal supply of 393 tons.		Coal per H. P. per hour.
		Per hour.	Per day.		Distance can steam	Days.	
Knots.		Tons.	Tons.	Knots.	Knots.		lb.
16	3,300	2·60	61·7	384	2,419	6·3	1·75
15	2,620	1·75	42	360	3,366	9·35	1·50
14	2,000	1·33	31·92	336	4,136	12·31	1·50
13	1,600	1·07	25·68	312	4,773	15·03	1·50
12	1,230	0·82	19·7	288	5,750	20	1·50
10	650	0·46	11·04	240	8,542	35·5	1·60
8	375	0·26	6·24	192	12,092	62·9	1·80
6	200	0·17	4·08	144	13,870	96·3	2

The motive power is furnished by two triple expansion engines, placed in separate watertight compartments, and develop with natural draught to 2,200 H. P., and forced draught to 3,300 H. P. The cylinders are 22, 31, and 50 in. in diameter, with 30 in. stroke. The pumps of all kinds will be driven by auxiliary engines. The two propellers are each three-bladed, and are 10½ feet each in diameter. There are four boilers, and are of the cylindrical horizontal pattern; each 9 ft. 6 in. diameter and 17 ft. 6 in. long; with a grate surface of 220 square feet.

There are two sets of dynamos to furnish a system of incandescent electric lighting throughout the ship. The search lights are of 25,000 candle power.

Armament.—The main battery is composed of six 6 in. breech-loading rifles, two on the forecastle and two on the poop, with the line of fire about 18 feet above the water. One is mounted on each side in the waist of a sponson, at a height of 10 feet from the water. The forward guns concentrate at 300 feet forward the stem, and the after two at 300 feet abaft the vessel, while three guns on one side can be concentrated at a point 100 feet from the side of the vessel. The secondary battery consists of eight rapid-fire guns and revolving cannon on the rail and tripod mounts. The Yorktown has eight torpedo guns or launching tubes, fixed ones, in the stem and stern, and three training tubes on each side. Automobile torpedoes will be fired from these tubes, and there is a complete outfit of boat, spar torpedo, gear, and charges.

The quarters for the officers are under the poop deck at the stern of the vessel, and are admirably lighted and ventilated. The crew's quarters are situated on the forward part of the berth deck, and are divided athwartship by steel watertight bulkheads, fitted with the necessary watertight communicating door. The dispensary and mess lockers are also located here. Great space and accommodation are also provided for the crew under the forecastle deck. The water closets for both officers and men are here located, as are the crew's wash rooms and galley inclosure.

Two 47 mm. Hotchkiss guns are located here, in the bow, and a large space left for the manipulation of torpedoes on each side.

The Yorktown was built at the yards of the Wm. Cramp & Sons' ship and engine building works, Philadelphia, Pa.

The first official trial of the Yorktown began on Feb. 12, and during a run at sea for four hours under forced draught she showed horse power largely in excess of three thousand and a speed greater than sixteen knots per hour. The *New York Herald*, from which we gather the following particulars of the trial, says:

Naval officers on board pronounced her one of the most valuable vessels ever built for the navy.

The trial trip began at half-past nine o'clock Tuesday morning, Feb. 12, the vessel leaving the shipyard of William Cramp & Sons, having aboard the official Board of Inspection and Messrs. William M. and Edwin S. Cramp and Mr. Horace See, of the ship-building company. The official board consisted of Commodore W. E. Fitzhugh, Commander E. M. Shepard, Chief Engineer G. F. Kutz, Naval Constructor R. W. Steele, and Lieutenant S. A. Staunton, all of the navy.

In addition to the foregoing, the following naval engineers were ordered to attend the trial to record the working of the machinery: Chief Engineers Robert Potts, C. Andrade, Ralph Astor, and R. B. Hine; Passed Engineers J. F Bingham, W. L. Cathcart, A.C. Engard, E.R. Freeman, and W. J. Rowbotham; Assistant Engineers Harry Hall, H. P. Norton, R. J. Reid, W. D. Weaver, and J. L. Wood, and Cadet Engineer W. L. Day. During the trial one of these officers was stationed at each of the important posts to observe the working, to record results, and to take indicator cards from which the horse power could be calculated.

About four hundred tons of pig lead was put into her in such places as to represent the missing weights. To represent her guns, lead weighing seventy-two tons was distributed in six piles near the gun ports, confined by heavy beams bolted together and to the deck. These weights brought the ship down to the required displacement of 1,703. Her draught at the shipyard in fresh water was 13 feet 4 inches forward and 15 feet 4 inches aft, or a mean draught of 14 feet 4 inches. This was equivalent to a mean draught in salt water of 14 feet.

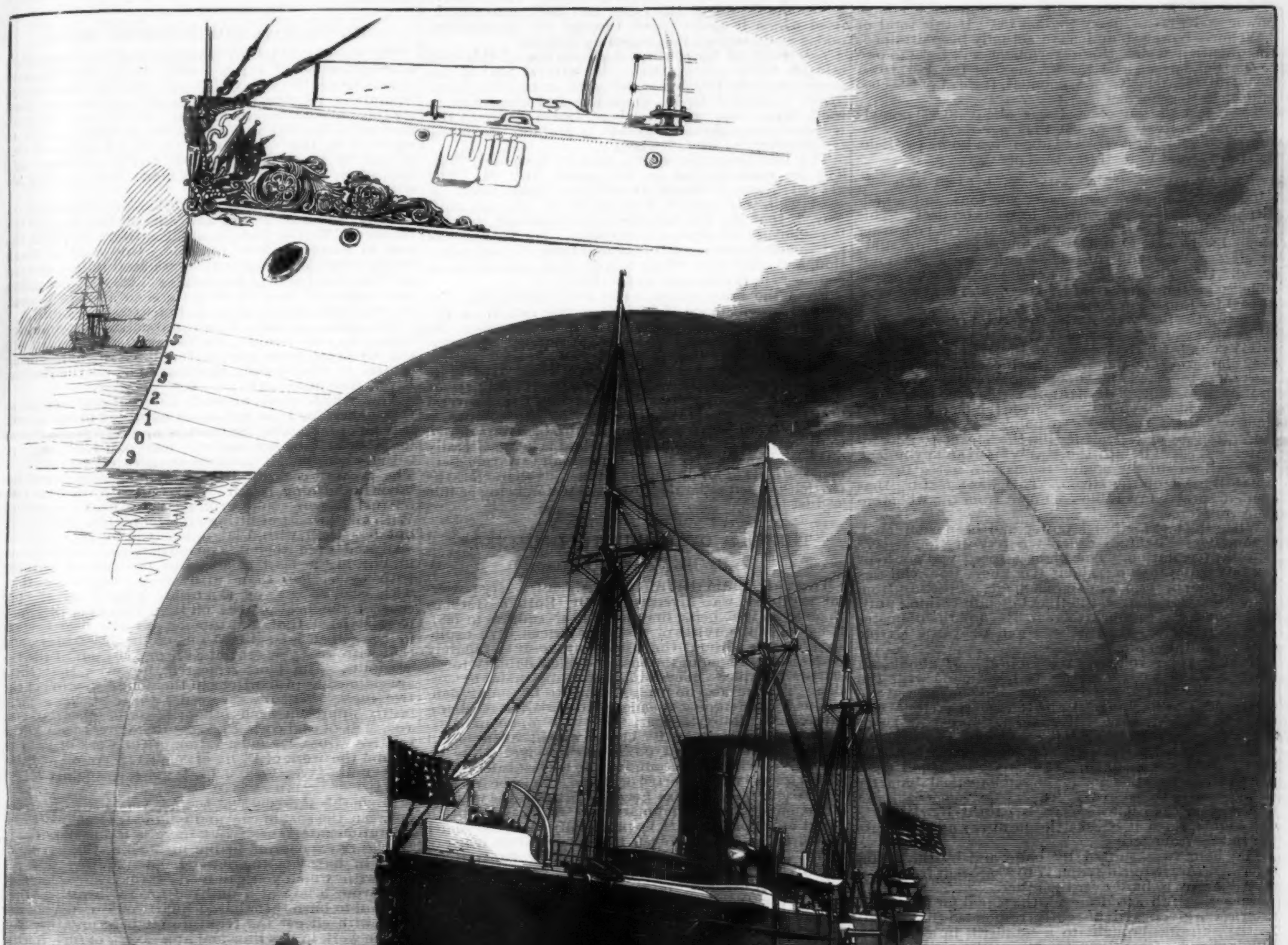
Down the Delaware Bay the run was made at a moderate speed of twelve knots per hour, and at half past four o'clock P. M., the Yorktown anchored for the night inside the breakwater. Captain Joseph Steele was in command, while the engines were in charge of John Patterson, superintendent of the erecting department in Cramp's shipyard, and his assistant, Nelson Johnson. There was a crew numbering forty-five men taken from Cramp's works.

The forced draught is used to bring the steam pressure up to the point which will develop the engines' full capacity, and calls for something more than the draught naturally caused by the burning coal. This is given by a "blower" making 800 revolutions a minute, drawing air either down four large ventilators or through the engine room. The fire room and the connecting coal bunkers are made air tight by closing the water tight compartment doors, and the revolving fan increases the air pressure in the fire room about one ounce and a quarter to the square inch above the normal atmospheric pressure. The air thus banked up rushes into the ashpits and up through the fire, and of course supplies such a draught as greatly to increase the consumption of coal and consequently the evaporation of water. An idea of the difference may be gained from the fact that while the natural draughts aboard the Yorktown produced only 2,200 horse power,

under forced draught fully 3,500 horse power was secured.

At nine o'clock Wednesday morning, Feb. 13, the Yorktown passed outside of the Capes of the Delaware, and forty-five minutes later, having worked up a steam pressure of 160 pounds, with 153 revolutions on each of the two engines, the official test began. The course was south-southeast, the wind was blowing strong on and as the steamer's top hamper—hull, masts, boats, and ventilators—caught the opposing wind, now somewhat stronger than at first, the speed was slightly checked; at a quarter past eleven it was 15·3 knots, and at a quarter to twelve it was 15·9. On heading directly against the wind, the speed at noon was found to be 14·9 knots per hour, a double-reef topsail breeze blowing.

The average speed shown by the chip log, hove at intervals of fifteen minutes, was 15·67 knots per hour. One of the taffrail logs registered a run of 67·3 knots for the four hours, and the other 61 knots, the mean being almost exactly 16 knots per hour. The taffrail log showing the shorter distance gave evidence of defective working, and will be tested to discover the correction necessary to be applied to it. As the run dead



THE NEW UNITED STATES GUNBOAT YORKTOWN.

the starboard beam, there was a moderate chop sea, and the air was cold and dry. Taffrail logs were set when the trial began.

The ordinary chip log, hove five minutes after the trial began, showed a speed of 16·7 knots per hour, and at ten o'clock the speed was found to be 17·2 knots.

After an hour's run on this course the ship was hauled up with the wind broad on the starboard bow,

At this time there was a fair swell and an ugly cross chop sea on, and heading into it the spray and even occasionally the top of a wave came over the forecastle. Nevertheless the motion, either from the sea or the vibration of the engines, was very little. A glass of water, filled to within one-eighth of an inch of the brim, was set on the deck at the stern taffrail and not a drop of the contents was spilled.

against the wind did not last as long as the run with the wind abeam, the average of the speeds shown by the casts of the chip log was below the actual distance covered. It is nearly certain that the average speed was in excess of sixteen knots per hour.

During the four hours' run the naval engineers took indicator cards at each end of every cylinder every fifteen minutes, making 192 cards in all for the four

hours. The indicators will be sent at once to New York to be tested for accuracy, and the cards will then be worked out in the Bureau of Steam Engineering of the Navy, in Washington. Until this is done no absolutely accurate knowledge of the horse power developed by the engines can be obtained. Enough is known by comparing the results found on this trial with those observed on the ship's four previous unofficial trials to be certain that the horse power developed greatly exceeds the 3,000 required by the contract. Engineers estimated that the main engines developed 3,400 horse power and the auxiliary engines 150. If this total of 3,550 horse power should have actually been attained, the premium which the government will have to pay to the builders will be $55,000, making the Yorktown cost $510,000 exclusive of armament, instead of $455,000 named in the contract.

The consumption of coal was about 10,500 pounds per hour, equivalent to 120 tons per day. The consumption going at a speed of about ten knots per hour has been found to be thirty tons per day.

WHAT DISTANCE HER COAL WILL TAKE HER.

The ship's bunkers will carry 400 tons, and an additional 80 tons can be carried in sacks on deck. This would enable her to steam for four days, covering about 1,600 knots, at full speed, under forced draught, or sixteen days, covering 3,840 miles, at a ten knot speed. Of course it would be difficult, if not impossible, to keep up the greatest speed and consumption of coal for four days consecutively.

During the four hours' trial the steam pressure ranged as high as 168 pounds, and at one time it fell as low as 145 pounds; but for most of the time it was kept very close to 160 pounds. The engineers on duty in the fire rooms reported an average temperature during the running under forced draught of a trifle over 70 degrees. They were almost enthusiastic over the fact that at no time was there the least "priming" of the boilers—"priming" being a tendency in the steam to take up water and carry it into the steam pipes and cylinders. The engineers in the engine rooms also noted the unusual dryness of the steam. This was a feature that excited special favorable comment from the whole engineering force.

When the test for horse power had been completed, Commodore Fitzhugh ordered a test of the vessel's powers of evolution. The highest speed was not kept up, but while making about ten knots the helm was put hard a-port and a full circle made. Starting from a nor'-nor' west course, the time taken in turning until that course was resumed was 5m. 33s., and the diameter of the circle was estimated at about 600 yards, a trifle over one-third of a mile.

Making 118 revolutions per minute, or about ten knots, a circle to starboard was then made with the helm hard a-port, the port engine going ahead and the starboard one backing. In this case the circle was made in 5m. 53s., with a diameter estimated at 150 to 200 yards. Again getting full speed ahead with both engines, the helm was put hard a-starboard and the port engine was stopped. The circle was then completed in 5m. 8s., with about the same tactical diameter as before—150 to 200 yards. These experiments showed that neither time nor distance is gained by reversing one engine, since it checks the headway and prevents the rudder from acting.

The helm was shifted by hand and by the steam steering gear, requiring from 17 to 25 seconds from hard over one way to hard over the other.

Gathering full speed ahead, the signal for full speed astern was given and instantly responded to. In 1m. 1s. the ship was brought to a standstill in about two hundred yards from the point where the engines were reversed. In 57 seconds more she had gained a speed going astern of about five knots an hour. These experiments closed the official trial.

The ship is of a convenient size for peace cruising, while as a commerce destroyer in case of war she would be highly available. It is true that she could not catch the so-called "ocean greyhounds," like the North German Lloyd, the French and the Cunard liners, but inasmuch as ninety-six per cent. of the steamships of the world have a speed below twelve knots per hour, it will be seen that the Yorktown would be able to overtake a good many merchant steamers and fully ninety-five per cent. of the war ships. Her draught, averaging only fourteen feet, gives her access to many ports not open to larger ships.

The steadiness of the ship in a sea-way and the rapidity with which she can turn, stop, and back give her great tactical value, since her guns can be more accurately pointed than on a crank vessel, and her ability to maneuver quickly and in small space can be appreciated even by non-experts.

GOOD ENGINEERING WORK.

During all the trial not a journal heated and not a drop of water was used to keep the bearings cool. This fact and the total absence of "priming" in the boilers are sufficient to make naval engineers regard the Yorktown with high favor, independent of her power.

When her engines were reversed, there was no such commotion or thumping under her stern as generally accompanies the backing of a screw steamer; indeed, it was difficult to discover from the motion whether the engines were going ahead or astern.

THE POETSCH FREEZING PROCESS IN AMERICA.

THE Poetsch-Sooy Smith Freezing Co. is at work on a shaft for the Chapin Mining Co., at Iron Mountain, Mich. In sinking for a newly discovered mineral ledge, quicksand was struck at 15 ft. below the surface, and another and larger stratum of the same was located 60 ft. below the surface. The final result of this discovery was a contract with Gen. William Sooy Smith and his company, the American owners of the Poetsch freezing process, to sink a 15 ft. shaft to a depth of 100 ft., some time last fall. The plan adopted was the same practically as that already several times described, but as this is the first American trial on any considerable scale, we will describe it in more detail, as reported in the Chicago *Tribune*.

Around a circle 29 ft. in diameter, 26 10-in. holes were bored in the ground. The task was not an easy one, the soil being full of stones and bowlders. Into these holes were inserted 8 in. wrought iron pipes, connected with malleable iron couplings and securely plugged at the bottom. Inside of these large pipes is a 1½ in. pipe, terminating within 10 inches of the bottom. At the top both series of pipes are connected with tubing of their respective diameters, which tubing leads to a couple of huge tanks in the freezing plant and engine house. The ice machine operates on a solution of chloride of calcium, reducing its temperature to minus 25° Centigrade, or about 17°, Fahrenheit below zero. This cold fluid is forced into the series of small pipes dropping to the base of the large pipes. The pressure forces the liquid up the pipes and back into a tank, from which it again passes through the ice machine and is again sent on its congealing mission.

The result of the continued circulation of this cold solution is the absorption of the natural heat of the ground and the freezing of the earth around the pipes. These congealed circles, gradually widening, form a solid, impervious wall, in whose frozen embrace the treacherous quicksand becomes as granite. Such was the discovery of Prof. Poetsch.

The Iron Mountain shaft is already down over 70 ft. The ice machine was set in motion Nov. 20. The ground began to freeze twenty-four hours later. A solid wall was formed Nov. 24, but it was not until Nov. 27 that Mr. Thomas, the superintendent, decided to commence the work of excavation. Mr. Thomas has kept an elaborate record of temperatures, lines of radiation, and other data which will prove of great value to engineers in future work of this kind.

From the examination made it was found that the ground at a distance of 70 ft. from the mouth of the shaft is frozen solid in a circle 15 ft. in diameter. In other words, the excavation is surrounded by a congealed wall over 14 ft. thick.

The original process has been much improved in its details since it has fallen into the hands of its present American owners, and in the past two years several patents have been taken out covering these improvements. The work at Iron Mountain is so far a thorough success, and the quicksand is being literally quarried like solid rock. The quicksand stratum here penetrated is of an unusually dangerous character, the particles, when separated from the water, being as fine as dust.

THE USE OF ROBURITE IN MINES.*

By Mr. JAMES HILTON.

THE author said that roburite, which is a very powerful explosive, was invented by Dr. Roth, a German chemist, in 1886, being first used in this country in 1887. It belongs to the class of what are termed high explosives, but is without the disadvantage unfortunately possessed by some, in the shape of their liability to accidentally explode in certain cases while under percussion. There is also no fear of roburite becoming dangerous by undergoing chemical, molecular, or mechanical changes. Roburite consists of two component parts, each non-explosive in itself, but which, when mixed with the other, forms a powerful explosive. It is especially valuable on account of the perfect safety with which it can be transported or stored. Neither friction, percussion, nor heat has been known to cause it to explode, and a strong detonation is required to bring about an explosion. It is practically flameless under pressure, the gases evolved in its combustion being of such a character as to quench any initial flame there might be.

In fiery mines, however, it should be tamped so as to confine the gases, and give them the chance of action on the initial flame at the moment of ignition, the quenching element being chlorine. Hydrochloric acid gas is given off on explosion, and this, being incapable of supporting combustion, prevents the spreading of the flame. The effect, he might add, is very similar to the water envelope in the water cartridge; but while in roburite the quenching element is certain to be always present, this is not so in the case of the water cartridge, either through the cartridge leaking, as he had known it do—the result being that a large flame came from the shot hole as the shot was going off—or through the shot firer willfully omitting to put water on the cartridge at all, which has been frequently done. With regard to the gases evolved by the decomposition of roburite, it appears from a memorandum by the inventor that there are no noxious nitrous fumes caused by its explosion. Like every other explosive—nay, every other combustible substance—it must produce a certain amount of carbonic acid gas, but an investigation has shown that these gases are perfectly harmless, thus bearing out the practical experience of all who have been present at explosions of roburite. After an experience gained in firing over 3,500 charges, he had drawn up the following rules for the use of roburite:

1. Roburite can only be exploded effectively by a very strong detonator containing one gramme of fulminate of mercury.

2. The drill hole should only be a trifle larger than the diameter of the cartridge, and is more suitable when machine-drilled.

3. Open one end of the cartridge, bore a hole down the center of it (with a wooden peg), then insert the detonator well into the middle of the cartridge, and next tie the covering of the cartridge firmly to the fuse.

4. In tamping, be careful to use dry material, and to ram the hole very lightly for the first three or four inches, so as to not displace the detonator or compress the roburite. Afterward, tamp firmly, for not less than a foot, with clay, or damped borings from the drill hole. This rule is most important, as the safety of the explosive depends on the tamping.

5. Fire the detonators with an electric fuse where firedamp is given off or coal dust is present.

6. Store the roburite in a dry place, and if the hole is wet, fire the charge as quickly as possible after it has been placed in the hole.

7. If the charge misses fire, disconnect the cable from the battery, and wait ten minutes before going to it, for, although there has not been a single case of hanging fire with me in over 3,500 shots, yet I have heard of an accident happening through a shot hanging fire for a few minutes. It is supposed that the paper at the end of the electric fuse, inserted in the detonator, smouldered for a short time, and fired the fulminate of mercury.

After giving the details of a large number of experiments, Mr. Hilton observed that in the number of roburite shots mentioned either sparks or a flash had been seen, on an average, once in a hundred times, but in none of these, in his opinion, would an inflammable mixture have been ignited, although the margin between danger and safety would have been small in such an event. He hoped, however, that if anything further could possibly be done to prevent sparking, the Roburite Company would do it, and thus render the explosive, if used with ordinary care, an absolutely safe one.

* Abstract of paper read before the Manchester Geological Society, at the meeting held at Wigan, January 11.

OIL VS. COAL FOR BURNING BRICK.

THE use of fuel oil for burning brick is not exactly a new utilization of this material, but it is sufficiently new to be yet in the testing stage, and any information from those practically handling the various fuels used for this purpose must be useful. At the late Memphis meeting of the National Association of Brickmakers, as reported in the *Clay Worker*, we find a paper on this subject by Mr. S. P. Crafts, followed by an interesting discussion, and from both we make the following abstracts:

After some introductory remarks, Mr. Crafts said:

As it would be a long and difficult task to give the values of different fuels in all localities, I will take the cost in southern New England. One cord of beech wood, worth $4, contains 17,065,000 heat units; one ton of bituminous coal at $4 contains 31,227,000 heat units; four barrels of fuel oil, 40 galls. each at $1 per barrel, at 6 lb. to the gallon, gives us 20,160,000 heat units.

Here, then, we have data based on the cost and heat values for one locality, the variation from which will not be large from any of the brick manufacturing centers in that region, in which I include the Hudson River, New Jersey, etc.

Now, which shall we use? I do not consider gas in this paper, for I do not know anything about it, and it is not practicable for most of us. The greatest cost for labor in burning, and the least cost for fitting up, is the wood, but it involves the greatest cost for fuel. The greatest cost for fitting up, and a smaller cost for labor in burning, is with coal, but with the least cost for fuel if you could utilize all the heat it contains. With oil, the cost of fitting up is more than with wood, but less than with coal, unless you build permanent wall, and even then it is somewhat less, and the labor in burning is least of all. But the cost of burning with oil is less than with wood, but more than with coal, unless you can utilize a much greater per cent. of the heat of the oil than that of coal. Now, it is claimed that you can get all the heat there is in the oil, at least 19,000 out of the 20,200 units, and that with coal you get but 8,000 or 8,500 out of the 14,-300 units. You must remember, however, that these are claimed as proportions in the pound weights of the two fuels. When we consider the cost, they more nearly approach each other; 12 lb. of oil costs 5 cts., and 12 lb. of coal costs 2 1-7 cts.; therefore, to get at the relative values, we must estimate the work of 12 lb. of oil and the work of 28 lb. of coal; 12 lb. of oil at 19,000 heat units gives 228,000 heat units, as against 224,000 at 8,000, or 238,000 at 8,500.

From this it seems that there is very little difference between the cost of coal and oil unless some other consideration intervenes. But there is a consideration of the lesser expense of fitting up for oil, the saving of time in burning, the fewer hands required, and the ease with which you can increase the heat. You may keep your bricks at a dull red for any length of time and fail to burn them hard; but if you can in a shorter time with oil get the requisite temperature, then you do the work in less time and at a saving of fuel, for the radiation of the heat of a kiln in six or seven days is no small item. It seems to me that in this shortening of time and saving thereby is the principal argument in favor of oil over coal, but it becomes us to consider whether the difference of the percentage of heat utilized under a boiler when burning oil or coal will hold good when diffused in and through a kiln of brick. I do not think it will, for a kiln seems to take up all the heat of combustion in either case, certainly until the last stage of burning, when the blanket of steam ceases to hold down the heat as in the earlier stages—a condition very different from the smoke stack of the boiler.

In summing up I should say that wood is the simplest and most expensive in most localities, certainly in localities where the greatest number of bricks are made; but that between coal and fuel oil it is an open question yet to be determined by a longer and more thorough test.

For myself, I have used coal over four years, at a cost of about 50 cts. per 1,000, and am now trying oil in the latter stage in burning to get a larger volume of heat and to deepen the color of brick when burned. We have just finished burning a kiln of 19 arches, containing 451,000 brick, using 67 tons of coal at $4.25 per ton, making the cost per 1,000 63 6-40 cts. This kiln of 451,-000 brick contains 15 tons of coal dust, as against 18 tons in the same number of brick made last year. This amount and the height (six bricks higher than last year) may account for the longer time and greater relative consumption of coal than usual; two hands to do the work. We set 52 bricks high to economize the shed room, but are satisfied that 46 high is better and more economical.

The reasons given above for the higher cost of burning do not hold good, for we have since burned a kiln of 474,000, made in precisely the same way and set the same height, at a cost of 50 cts. per 1,000. Cause, better coal.

Mr. D. V. Purington, in discussing this paper, said:

I have burnt this year a little over 28,000,000 bricks without using a stick of wood or a pound of coal—entirely with oil. Of course my brick are artificially dried. We have taken out of each brick from the time it was made till it was set in the kiln a pound and a quarter of water; so they are about as dry as can be got, practically. We start one side of the kiln three or four hours before we do the other, and we get the heat up just as fast as we can get the draught started. When we first start, of course without the arches being heated at the sides to aid the combustion, we have to burn more oil. Our fire is oil, and we burn on an average four days, where the average was about seven days and a half before. I burn in kilns of 24 arches each, and where we used five men before, we now use two. We have no ashes to haul away, no coal to unload. We unload all our fuel with a little steam pump, and it is then ready to be drawn by gravity from the tank to

the kiln. I can state unequivocally that I know of no inducement other than a pecuniary one that would lead me to go back to burning common brick, artificially dried, with wood or coal. I'm not up on heat units and shall endeavor to talk in a language that brickmakers can all understand. I don't know a unit of heat; wouldn't know a dozen if I should see them right here. The cost for fuel has been, for oil, an average of 36½ cts. per 1,000. In the beginning, before we understood oil and its uses, we used a great deal more, and we are all the time improving upon it. Any science so new as the burning of brick with crude oil is susceptible of great changes, and I expect it to improve for the next ten years. The exact total cost of burning brick so far with me I have been unable to ascertain, for this reason—I take my steam from a stack of three boilers, and the same steam from the three boilers is used for running my machines in the day time, and also for my kilns, and for burning brick. So I have been unable to divide the amount of steam I use for burning brick, and the only way I can get at it is relatively, and my figures show the total cost for labor, fuel, oil, and coal for burning brick this year has been 52 1-3 cts., as compared last year with 22 cts. using wood and coal.

THE POISON OF TYPHOID FEVER.*

By CYRUS EDSON, M.D., New York.

NOTHING is more discreditable to the civilization of the nineteenth century than the existence of typhoid fever.

Wherever men are congregated together in houses and villages, typhoid fever is endemic.

From Greenland to India, from England to China, it holds sway. Yet of all diseases it is the most easily preventable, scarcely excepting small-pox.

Careful scientists have isolated its germ and taught us its characteristics. Numerous observers have shown us under what conditions the germ is best propagated, under what circumstances it perishes, and what agents best effect its destruction, yet their teachings seem utterly lost upon mankind, for people go on year after year drinking polluted water and spreading the disease. During the past year I have visited twenty towns supplied by water from dug or driven wells. In every instance the supply was polluted, and in the case of twelve was responsible for an outbreak of typhoid. The other eight were wanting only an initial case to infect the water supply and cause an epidemic.

After investigation of many cases I have come to the conclusion that typhoid fever is rarely due to any other cause than polluted water, milk, ice, or meat. The first-named is, of course, the most common. I can readily imagine that other means of spreading the disease may occur, and in the course of this paper will instance other possible causes. I assume the following propositions as having been established by Chantemesse, Vidal, Brouardel, and other investigators with whose works you are familiar:

1st. That typhoid is due to a germ, the bacillus typhosus.

2d. This germ is contained in the sputa and stools of typhoid fever patients.

3d. The bacillus typhosus is easily destroyed by disinfection of infected stools and sputa by means of efficient agents, such as heat, mercuric bichloride, and carbolic acid.

No method of illustration is as convincing and striking as that of citing actual examples of the methods by which the disease is propagated. I will, therefore, give you records of a few authentic cases. Each case illustrates a different method of infection.

For the following instance, which shows how a perfectly pure water supply, through ignorance, may become accidentally infected, I am indebted to Dr. John H. Girdner, of this city, who, a short time ago, had occasion to visit a small town in North Carolina, and while there was asked by a resident practitioner to see some cases of typhoid in the family of a farmer residing in a little settlement near by. The local medical man could not account for the outbreak, and had attributed it to a wave of the disease sweeping over the country. Dr. Girdner's curiosity was excited and he determined, if possible, to ferret out the causes. Of course his first step was to look after the water supply. This he found was from one source for the entire hamlet—a clear spring, situated at the base of a cliff, perhaps ten feet high, and at such a distance from any source of drainage or privy contamination as to exclude both. Above the spring the cliff leveled off on a stubble field from which a crop of some cereal had been cut and the ground plowed and harrowed. The direction of the harrow furrows and the pitch of the surface was toward the spring; a couple of hundred feet to one side, but on a lower level than spring or field, stood the farmhouse. Dr. Girdner ascertained that the first case of the disease occurred in this house, and on asking the country physician how the dejecta were disinfected, was told that they were thrown away at a distance from the house, and disinfection was left to the sun and fresh air. As they entered the farmhouse they met an old woman carrying a vessel under her apron. The country doctor was about to stop her, but was restrained by a gesture from Dr. Girdner. She walked to the stubble field, proceeded until she reached a point just above the location of the spring, then she gave the contents of the vessel a toss, and walked calmly back to the house. Here was the cause of the epidemic. The rain washed the poison down the harrow-furrows into the spring. Another water supply was obtained, careful disinfection of the stools practiced, and no other cases occurred.

A nearly parallel case was that of the Plymouth, Pa., epidemic. Nearly thirteen hundred persons developed typhoid from infection by the typhoid poison from one individual who resided on the bank of a small mountain stream supplying the town with water.

Typhoid fever is most frequently propagated by contaminated well water. It is safe to say that scarcely a well exists in this country the water from which is safe to drink.

Wells are popular because they are convenient. Almost anywhere a well from ten to forty feet deep will furnish clear, nice-tasting water that will impress an uninitiated observer with its purity. The country well represents a type described in the Bible under the simile of a "whited sepulcher." It is sunk as conveniently near to the house as possible, often under the floor of the kitchen. It is the habit of the countryman to sink another hole, also as conveniently near as possible to the house—his privy. Now, the well draws its supply from an inverted cone, the base of which is at the ground surface. The privy, on the other hand, contaminates a cone, the apex of which is near the surface and the base of which is on a level with the bottom of the well. This gives you an idea of how far-reaching privy contamination is as regards well water.

So many examples of well water causing typhoid present themselves that it is embarrassing to make a choice for the purpose of illustration. I will take one, however, that occurred in September last, at a New Jersey seaside resort. A charitable institution, and a most worthy one it is, has a country house at this place. Six of its children came to this city, and shortly after their arrival developed typhoid. I investigated the water supply of the country branch and found it to be from a well. A sample of the water analyzed by the Health Department chemist was shown to be contaminated by sewage. The location of the well and that of the privy showed the latter to be the source of the contamination. The privy had been the receptacle for typhoid germs from the bowels of a patient sick with the fever about three weeks before the children were affected.

Ice from infected water has been shown, in an able manner, by Dr. T. J. Mitchell Prudden, to be a source of danger. The typhoid germ is not destroyed by extreme cold. The germs that caused the Plymouth epidemic, already referred to, were exposed to a temperature of 22° below the Fahrenheit zero on the banks of the stream subsequently infected by them after a thaw occurred.

I am indebted to Dr. Fordyce Barker for the following account, illustrating the propagation of the disease by ice, though this epidemic, I regret to say, has not as yet been carefully investigated; its facts, consequently, cannot be vouched for by Dr. Barker; nevertheless, it is probably essentially true. I only learned of it recently, but will take an early opportunity to personally investigate the conditions and data. Twenty-two cases of typhoid fever developed at a popular watering place in this State during one of last summer's months. It was found that only those who used ice from a lake near by were affected. This ice was cut from a point near the entrance of a sewer that drained the town, or a portion of it. The use of this ice was stopped, and the epidemic ceased.

Milk may be the carrier of typhoid germs, and may become infected in two ways.

First, through the water supply, as the following instance, related to me by Dr. William M. Smith, will show: A country town in this State developed a large number of cases of typhoid fever (nearly two hundred), and investigation showed that only the customers of a certain milkman were affected. His well was examined and found to be contaminated by the drain of a neighbor's house in which a case of typhoid had recently occurred. The milkman admitted washing his cans with the well water, but it is probable that he was no better than the others in his business, and occasionally utilized his pump for cow purposes. The infection of milk may possibly be accounted for in another way. It is this: the cow may take into her digestive tract the germs of typhoid, she may or she may not develop the disease (that cows are affected with a disorder that resembles typhoid fever is well known), but even if the germ produces no evil effect on the cow, it is a reasonable theory, and I advance it, that cultures of typhoid bacilli may be developed in the intestines of the animal who drinks water infected by them, and that her dung will be thus infected. Now, milk always contains an appreciable quantity of cow dung. I have seen the Lazell separator, a centrifugal machine for skimming milk, remove from one thousand quarts of milk as much dung as one could hold in both hands. This dung is detached from the udder, to which it adheres, by the operation of milking. I intend trying a series of experiments, with the object of demonstrating this theory, and hope to invoke the aid of Drs. Prudden and Biggs, the pathologists to the Health Department.

The point I desire to make in this paper is that typhoid fever is essentially preventable, because its poison is always tangible, and must be taken into the stomach and intestines in order to produce the disease; that, like cholera, it can never infect through the medium of the atmosphere, but must enter the stomach of man in food or drink, or on some infected article placed in his mouth. The strongest arguments advanced against this view have been those made by Volz, Herman Schmidt, Budd, Murchison, and Hutchinson. The latter writer states follows; "Typhoid fever may be propagated in consequence of contamination of the atmosphere by typhoid poison. This may be the result of allowing the undisinfected stools or linen soiled by them to remain some time exposed to the air, or may arise from pollution of the soil from the same cause, or from defective drainage." He quotes Herman Schmidt, who cites several outbreaks in German garrisons which he believed to be due to soil pollution, where the ground underneath was found saturated with all kinds of impurities.

In one case the water supply was found impure and cut off, yet the epidemic persisted. He does not state, however, what the water supply was, or describe that which was substituted in lieu of the one cut off, nor does he in any one of the cases alleged to have been caused by contaminated air describe the water supply, the ice supply (if the latter existed), or that of milk. He merely gives the fact that gross defects were found in drainage, or that extremely filthy conditions existed. We acknowledge that atmospheric contamination by the typhoid poison is impossible when we admit, as we do, into our general hospitals cases of the disease, and treat such cases in wards filled with patients sick with other ailments. Here, if anywhere, the atmosphere would become infected were it possible to so infect it. Here, if anywhere, the disease would find suitable subjects to attack. On every side are persons debilitated and bedridden, who would easily develop the fever if the germ were once introduced into their systems. Do they? I have never known a case to be so caused, and I doubt if any of the experienced gentlemen here can instance such a case. Even if you can, it is such a rare occurrence that other causes must be assigned to it.

If atmospheric infection were possible, New York City would have been almost depopulated during the period before the Health Department was able to effect reform in methods of plumbing. Most houses in those days were charged with sewer emanations, which were poured into them through their defective and trapless pipes. The following table gives the number of deaths caused by the disease from 1866 to 1876, inclusive:

1866	514	1872	364
1867	348	1873	294
1868	320	1874	275
1869	378	1875	247
1870	422	1876	263
1871	239		

This does not show a very powerfully exciting or even predisposing cause. Assuming the average death rate of typhoid to be twenty per cent., 239 deaths—the smallest number occurring in any one of the above years—would represent 1,195 cases, a sufficient number surely to infect the sewers.

The observers who defend the theory that the disease originates *de novo* are negligent in respect to description of causes that must be excluded before their theory can be accepted as proved. In his *brochure* on the subject, Dr. Hutchinson, recognizing this fact, expressly states that the theory that the disease originates spontaneously cannot be accepted, because cases on which the theory is based can be accounted for by the proved fact that the germ may be latent for long periods, under certain conditions, awaiting favorable conditions to be fanned into activity.

Hutchinson cites the following instance, recorded by Von Gioth, in proof of this:

"To a village free from typhoid an inhabitant returned suffering from the disease, which he had acquired at a distant place. His evacuations were buried in a dunghill. Some weeks later five persons who were employed in removing dung from this heap were attacked by typhoid fever; their alvine dejections were again buried deeply in the same heap, and nine months later one of two men who were employed in the complete removal of the dung was attacked and died." This instance might be taken as showing that the disease can be transmitted through the medium of the atmosphere, but when it is remembered how easy it is by means of infected hands to infect food, and that this was the probable manner of infection, we must doubt this to be a case of atmospheric infection. I believe that typhoid fever, like cholera, is frequently caused by infected hands. A walking case of typhoid fever is likely to leave its traces wherever it goes.

In the act of using paper after defecation the fingers are soiled. The most careful use of paper or cloth scarcely prevents such soiling. The sputa containing the germs, as has been shown by Ludwig Letzench, may also infect the fingers.

Door knobs, banisters, etc., may receive a sufficient quantity of the poison to infect the hands of those who subsequently touch them, and the germs may thus be transferred to food or drink. Of course, in case of this method of infection, it would be nearly, if not quite, impossible to trace the mode of infection, though if we reject the theory of atmospheric infection we can account for such cases as the last described in no other way than that of digital infection. The scrupulous care exercised by the surgeon, who cleans and disinfects his hands and finger nails before an operation, shows his appreciation of digital infection by disease germs.

It has been claimed by competent observers that meat of animals sick with typhoid fever at the time of slaughtering will produce the disease in persons eating it. The epidemic that occurred at Kloten, near Zurich, has been widely quoted in defense of this theory. In 1878 a festival was held at this place, and of the 690 persons who partook of the meat served at the banquet 290 were taken sick with typhoid fever. Three hundred and seventy-eight people who did not attend the feast, but who ate the meat elsewhere, were also affected. Besides these, forty-nine persons who had not eaten the meat were taken ill subsequently, and their illness could be accounted for by infection from the first cases; in other words, they were secondary cases. All sources of infection other than that of meat could be, and were, carefully excluded. The place was free from typhoid, and it was clearly shown that the water did not cause the disease. All persons who ate no meat escaped, as did those who drank sufficient wine to cause them to vomit. All symptoms of typhoid were present, and post-mortem examinations of those who died showed all the lesions of typhoid fever. It was found that forty-two pounds of veal was furnished by a butcher who had taken it from a calf that was moribund from disease at the time of killing. All the meat of this animal was sent to the festival at Kloten, but the liver was sold to a man at the town of Seaboch, and the brain was sent to the family of a clergyman in the same town. The former got typhoid fever, and the entire family of the latter were attacked by the disease. It was also ascertained that another calf, in the hands of the butcher, was diseased, and the veal from this calf was in a decomposed state. All this meat was kept for some time in a refrigerator in the inn at Kloten, where the festival was held, and this refrigerator was found to be in a horribly filthy condition. Some curious facts were noted in this epidemic: The victims had more abdominal pain than is usual in typhoid fever, and the period of incubation was very short, some of the cases developing on the second day, and the majority between the fifth and ninth days. Dr. Hutchinson, to whose article I am indebted for the account I have just given, states that the short period of incubation is characteristic of all cases of typhoid fever caused by infected meat.

During last fall, with the assistance of Dr. Charles S. Benedict, I have investigated 146 cases in this city, between Twenty-third and Forty-second Streets, taken in succession from the records. Of these, 72 were out of town during the thirty days preceding the attack, and 34 of the 72 had been in places known to be infected by typhoid. Seventy-five had not been out of New York, so far as could be learned. Of these 75, 17 were traced to recognized causes; 12 were due to the following method of infection, which was discovered by investigation; of these, six cases of typhoid fever were reputed as occurring in a tenement house in West Thirty-second Street.

The first case in the house occurred on August 15, and was in the person of an employe of the Department of Public Works, whose duty it was to clean and repair the public sewers. The other cases appeared in from twenty to sixty days after the first. The plumb-

* Read before the Section on Hygiene and Public Health of New York Academy of Medicine.

ing of the house was carefully examined, and no defects were found. I visited the premises with Dr. Benedict, and found that the school sink privy in the yard was flushed by means of a branch from the Croton supply pipe, introduced in such a manner that its mouth was just under the surface of the contents of the sink when the latter was full. On account of the insufficient water supply a force pump was provided in the hall of each floor of the house above the first story. No fixtures were placed in the living rooms, the occupants of the different floors being compelled to obtain the water they used from the pumps in the halls. The supply to the school sink was provided with the usual valve to cut off the water, but this valve was always turned on so as to allow a stream of water to constantly flush the sink. When two pumps were being operated at once, the suction induced was sufficient not alone to draw from the Croton main, but also to suck a portion of the privy contents into the water pipes, thus contaminating the water. The amount drawn in was not enough to attract the attention of the tenants by the taste imparted to the water. The other six cases attributable to this cause were in a house in West Thirty-seventh Street, and the conditions found were the same as those I have just described. The first case, however, in this latter instance, contracted the disease in the country. No less than eight other houses, the water supply of which was thus contaminated, have been found by inspectors of the Health Department, but only in these two instances, so far as is known, has typhoid fever been caused by such conditions.

Four cases of typhoid fever, occurring in boys, during September, who had not been out of New York, investigated by Dr. A. H. Doty, of the Health Department, was traced to the following cause: All were in the habit of bathing daily in the East River, near the mouth of a sewer on a line of which several cases of typhoid fever existed. In these cases no other cause could be assigned for the sickness except the one given, which I think is doubtless correct. The 57 remaining cases not accounted for were probably due to infected ice, milk, meat, or to digital infection. You will be interested to learn the relative prevalence of the disease in this city during the fall of 1887 and that of 1888. It is as follows: September, October, and November, 1887, 485 cases, 105 deaths; September, October, and November, 1888, 557 cases, 132 deaths.

The points I have sought to establish may be summed up as follows:

First. Typhoid fever never infects the atmosphere.

Second. Typhoid fever never arises *de novo*.

Third. The causes of the disease, in order of their frequency, are as follows: 1st, infected water; 2d, infected milk; 3d, infected ice; 4th, digital infection; 5th, infected meat.

In this and in other civilized countries laws are enacted for the purpose of protecting the community from the accidental and criminal use of poisons. Yet, while wise law makers have recognized the necessity for restricting the distribution of those deadly but useful substances produced by man from the animal and mineral and vegetable kingdoms, they have not recognized the thousandfold greater necessity for restricting the distribution, by means of polluted well water, of the more deadly and useless poison which causes typhoid fever.

As I have already said, typhoid fever is pre-eminently a preventable disease. Its poison has been isolated; its characteristics are known. We know how and by what circumstances it is multiplied and propagated. It is well within the bounds of possibility for a person acquainted with these facts to use it for criminal purposes, and to almost defy detection; and yet against this insidious and deadly poison in the hands of the ignorant or careless we have no safeguards. On every side we are exposed to the danger of being infected by such people with the poisonous agent that has for its effects the train of symptoms called typhoid fever.

If in every case of typhoid fever the stools and bedding were effectually disinfected, and the person of the patient after convalescence was also disinfected, typhoid fever would soon cease to exist. Even if these measures are not observed, nevertheless the danger of taking the disease can be reduced to a minimum by such precautions as can readily be taken by any one who knows the characteristics of the poison and utilizes his knowledge to avoid its dangers, such as never drinking well or ice water, avoiding milk that has not been boiled, and by washing the hands before eating.

The death from typhoid fever of those whose negligence or disregard of the known laws of nature indicates stupidity or indifference is a striking illustration of the operation of the law of the survival of the fittest. It should be remembered, however, that this law applies in the economy of nature to the lower animals and not to man, since the distinctive difference between man and the lower animals is found in his ability to adjust his surroundings in conformity to his actual needs and requirements; whereas the animal is unable to do so. We may therefore assume that the human being who ignorantly subjects himself to conditions which menace his life is reduced to a plane with the lower animals, since he neglects to provide such surroundings as are conducive to health and longevity. Let the principles of hygiene be carefully taught throughout the country; let ignorance be removed in this manner, and typhoid fever will stop its work.

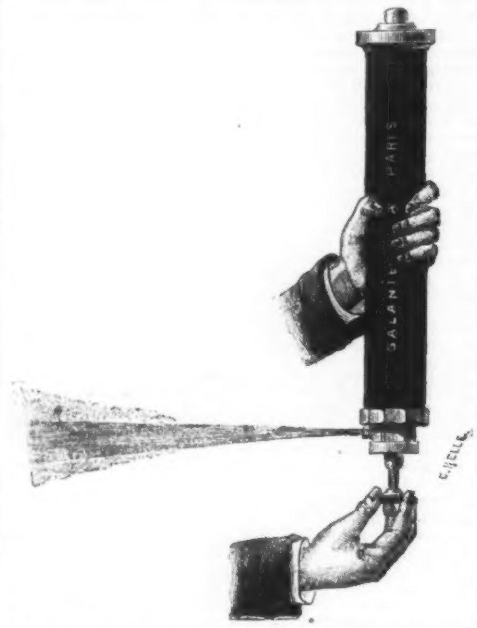
It has been alleged in the public press that the Health Department of this city is doing nothing to prevent the ravages of typhoid. This is not true. Every case of the disease reported is visited, and in tenement houses instruction is given by competent men concerning disinfection. Disinfectant agents are also furnished. All possible local causes are looked for, and if they are found to exist, they are removed. The result is that secondary cases seldom occur.

During the months of September, October, and November, ten physicians employed in this work made 2,593 visits to houses containing contagious diseases. This cost the city about forty cents for each inspection. The time taken for many of these visits was not less than an hour, and some took a longer period.—*Medical Record.*

An excellent method for cleaning the hands is to put ¼ pound Glauber's salt, ¼ pound chloride of lime, and 8 ounces of water into a little wide-mouthed bottle, and when required for use pour some of the thick sediment into a saucer and rub it well over the hands with a nail brush.

CHLORIDE OF METHYL SPRAY IN NEURALGIA.

Since Dr. Debove* showed how valuable the spray of liquefied chloride of methyl gas was in the topical treatment of various neuralgias, the literature of the subject has grown considerably, and many cases of cure resulting from the application of the spray to the skin over the neuralgic area have been recorded.† The gas, however, had to be liquefied by pressure, and the cylinders containing it were bulky and complicated. Galante et Fils, of Paris, have lately made for Dr. Debove (Feb., 1888) a small portable cylinder which has brought the method into general use in France. The cylinder is represented in the engraving, and the reader will notice that by turning a milled headed screw at the bottom of the apparatus, a fine spray jets out from an aperture just above it. This spray can be regulated to a nicety by the screw. A correspondent, who has recently tested the method (the charged cylinders being courteously supplied by Messrs. Christy & Co., of Lime Street), reports that he has employed it in over fifty cases with the following result: "The action of the spray upon the skin is remarkable. Such intense cold is instantaneously developed that, directly the chloride of methyl touches the skin, the latter becomes hard, iced white, and frozen. At the same time the patient feels as if he had been touched with a hot iron. Two seconds, or at the most five, are quite long enough for its application to any one patch of skin, for the skin will rapidly vesicate, and even become gangrenous, if the spray is continued for a longer period. It is better to play the spray *obliquely* over the skin, letting it glance off, rather than direct it straight at and in close proximity to the part. It has been used in France for extracting teeth painlessly, also in minor operations for local anæsthesia, and is recommended for trigeminal neuralgia. Concerning



the last, I would at once dissuade others from using it upon the face, for the application leaves a most disfiguring brown coloration, which takes a long time to fade. Of its value in the treatment of neuralgia there is no question. I have taken fifty cases of various neuralgias of the neck, back, testicle, urethra, and legs, and have relieved many temporarily and some permanently by its use. It is a rapid and effective vesicant, and has proved of value as a substitute for the often useful plan of 'firing' joints. As a 'moral' force in neuromimesis and malingering it will doubtless be most persuasive."—*Lancet.*

NEW METHOD OF DETERMINING CARBONIC ACID IN SOLUTION.

By Leo Vignon.

Carbonic acid in an aqueous solution, whether free or combined with the neutral carbonates, rapidly decolorizes the red liquid formed by mixing 50 c. c. of lime water and 10 drops of a saturated alcoholic solution of pure phenolphthalein. Hence it results that carbonic acid dissolved in water, free or in a state of semi-combination, can be determined volumetrically by means of a standard solution of calcium hydroxide, using, under suitable conditions, phenolphthalein as an indicator.

The details of the process are as follows: 50 c. c. of the water in which the carbonic acid is to be determined are mixed with 0·05 c. c. (10 drops) of a saturated alcoholic solution of phenolphthalein, and there is gradually added to the liquid lime water which has been previously standardized (by means of decinormal sulphuric acid and cochineal) until it takes and retains the rose shade which is characteristic of phenolphthalein in presence of an excess of lime. In order to obtain constant results, it is necessary to compare the final tint with that of a liquid of the same composition as the water to be examined, but perfectly free from carbonic acid. As a type there may be used either water recently distilled or a portion of the water under examination, which has been boiled long enough to expel all carbonic acid.

Fifty c. c. of each of these two liquids, raised to the same temperature, are placed in two test glasses on feet, graduated, having ground glass stoppers, and not exceeding 2 or 3 cm. in diameter. Into each glass are put 10 drops of the alcoholic solution of phenolphthalein, and we then begin to color slightly the type liquid with a measured quantity of standardized lime water added from a burette graduated in tenths of a c. c., without reaching the maximum coloration which can be produced. 0·2 to 0·5 c. c. will mostly suffice.

The solution of lime is then gradually added to the water under examination. The color produced by the contact of the lime water disappears very rapidly on agitation at the beginning, so long as carbonic acid is found in the liquid in sufficient excess. Toward the end of the reaction the combination of the lime with the carbonic acid takes place more slowly; it is therefore convenient to agitate the liquid frequently and to add the lime water at longer intervals. Care must be taken not to let the color in the water in question exceed the intensity of color of the type. When the coloration of the sample no longer varies, which occurs after an hour, if the precaution has been taken to agitate frequently, the type is made up to the same volume as the water to be examined, and an identity of shade between them is effected by adding lime water to that which is palest.

The two glasses are used like the tubes of a colorimeter. On examining them against a white ground we may, with a little practice, detect the shades of color due to the addition of 0·1 c. c. of lime water. When the colors are identical, we know that the two liquids contain the same quantities of free lime. The difference between the lime consumed by the water under examination and that which has served to color the type corresponds to the carbonic acid sought for.

The presence of calcium and magnesium chlorides, sulphates, and nitrates does not affect the results. Calcium carbonate, indeed, colors phenolphthalein slightly, but, besides that this coloration is not comparable in intensity to that yielded by free lime, it is not manifested in the presence of carbonic acid.

If the water contains alkaline salts, the acids of which are capable of forming insoluble salts of calcium or magnesium carbonate, which is slightly alkaline before titration, a little neutral calcium chloride must be added to convert the magnesium carbonate and the alkaline salts into chlorides. This peculiarity may be detected by the color which the water, after being boiled in a platinum capsule, will take with phenolphthalein.

If the water contains much carbonic acid, the calcium carbonate renders the liquid opaque, and does not permit of a colorimetric comparison with the type. This inconvenience may be remedied by adding to the colored type a little pure calcium carbonate, or by letting the calcium carbonate in the sample under examination have time to settle.—*Bulletin de la Soc. Chimique de Paris; Chem. News.*

ACTION OF SODA AND VARIOUS ACIDS ON COTTON.

M. Albert Scheurer has recently presented a paper on this subject to La Societe Industrielle of Mulhouse, in which the following data relating to the weakening of the cotton fiber are given. Strips of unbleached cotton cloth, 4 cm. wide, were submitted to the action of solutions of caustic soda of different degrees of concentration, at a temperature of 150° C. for eight hours. Dynamometric tests were made on ten strips, both before and after immersion, with the following results:

Strength of solution.	Mean resistance of ten tests.
10 grm. of soda per liter of water	16·4
20 " " " "	16·6
40 " " " "	15·8
80 " " " "	16·8
Original cloth	16·9

Under these circumstances, therefore, caustic soda, even when used in solutions containing 80 grm. per liter, does not weaken cotton fibers. It had been observed in some previous experiments that the presence of air bubbles protected the cloth from the action of solutions, and in the present instance the cloth was moistened with alcohol before being submitted to the caustic lye. By this means the absorption of the solution by the fibers was facilitated, and the effect of air bubbles avoided. The action of gaseous hydrochloric acid was next tried. A small quantity of concentrated hydrochloric acid of commerce was poured into a vessel, and pieces of bleached cotton cloth were suspended in the vessel, above the liquid, so as to be exposed to the fumes only. The experiments were conducted at the ordinary atmospheric temperature, about 20° C. The very injurious action of these acid fumes will be realized from a perusal of the following figures:

Period of exposure.	Mean resistance of ten tests.
Before exposure	24·3
After 10 minutes	15·0
" 20 "	14·6
" 40 "	9·6
" 80 "	6·0

It will be observed that, even within the small space of ten minutes, the cloth had suffered considerably, while after an hour and twenty minutes it had become practically worthless. Similar experiments were made with gaseous nitric acid, or nitrous fumes. Commercial nitric acid, 36° Be., was employed, the experiments being otherwise the same as those with hydrochloric acid. The results were as follows:

	Resistance.
Before exposure	24·3
After 10 minutes	21·7
" 40 "	18·7

It would therefore appear that although nitrous fumes are very injurious, they do not damage cotton fiber to the same extent as hydrochloric acid fumes do, when the cotton cloth is exposed to each for the same length of time, at the same temperature and atmospheric pressure. It must, however, be remembered that the tension of the vapor of commercial hydrochloric acid at 19° Be. is greater than that of nitric acid of commerce at 36° Be.; therefore the latter acid would be more rarefied or dilute than the former in the atmosphere of the vessel in the above experiments. Therefore the results only represent the measure of the comparative action of the vapors emitted by the two liquids under the stipulated conditions.

The results of experiments with sulphuric acid are given in the next table. The cotton, before treatment, had a resistance of 24·4. The solution contained 2 grm.

* Soc. Med. des Hop., Aug., 1884.

† Vinay: Lyon Medical, 1885, p. 350 (twenty-one cases, with seventeen cures). Peyronnet: These de Paris, 1886. Vinard: Gaz. Med. de Nantes, 1885. Also Robin, Rendu, Letulle, Sacre, Nerval, Tenneson, and Beque, and many others.

of 66° sulphuric acid per liter of water. The cotton fabric was immersed in this solution at a temperature of 83° C. in the first instance and of 90° C. in one lot of experiments, with the following results for different periods of immersion:

		Resistance.
1.	Not treated	24·4
2.	After 15 minutes	24·0
*3.	" 30 "	24·0
4.	" 30 "	22·0
5.	" 30 " at 90° C.	20·1
6.	" 30 " at 83°, with solution containing 4 grm. 66° sulphuric acid per liter of water	22·6

These samples were afterward subjected to the action of a boiling solution of sodium carbonate for a quarter of an hour, containing 2 grm. of the salt per liter of water. The resistance was then tried, with the following results:

Sample 1	24·1	Sample 4	17·9
" 2	23·5	" 5	20·1
" 3	22·6	" 6	21·5

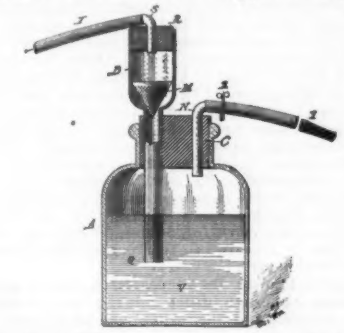
These tests with the sulphuric acid at 80° C. indicate that the weakening only takes place after half an hour, whereas at 90° C. the action is much more energetic; but the subsequent boiling with sodium carbonate reveals a loss of strength, increasing with the length of period of immersion in the sulphuric acid, while no excessive weakening is observed in this instance in the sample exposed to the higher temperature.—*Industries.*

* There is apparently some mistake in the time given in this instance.

SULPHURETED HYDROGEN APPARATUS.

THE following sulphureted hydrogen apparatus has been used with success in laboratory work.

A is an ordinary glass bottle with somewhat of a large neck, having a tight fitting rubber stopper, C. B is a glass bolt-head flask having the bottom cut off. An Argand lamp chimney will answer the purpose. The neck of this flask passes through the stopper, C, into the bottle containing dilute sulphuric acid. M is a small cone-shaped lead disk, with numerous holes in the bottom. The neck rests against the shoulder of the flask, B. R is a rubber stopper through which



passes a glass tube, S, to which is connected a piece of rubber tubing, T, to convey the sulphureted hydrogen gas to a wash bottle. N is a bit of glass tubing passing through C, next to the neck of the flask, B. To *n* a piece of rubber tubing is attached, having a stiffly working pinch cock, *x*.

To charge the apparatus: Take out the stopper, *c*, and place in A dilute sulphuric acid till the height of the liquid in the bottle is but a *fraction* of an inch above the neck of the flask. Next place some lumps of iron sulphide in the disk, *m*, and put the stopper, R, in place.

By opening the pinch cock, *x*, and blowing slightly through tube, *y*, the acid in *a* will rise in flask, B, and attack the iron sulphide in the leaden disk. As soon as the acid reaches the iron, close the pinch cock, and the gas will come off copiously. To stop the supply of gas, open the pinch cock, and the liquid, by gravity, will fall back in the bottle.

It is necessary before opening the pinch cock to take off the tube, T, from the wash bottle, as the liquid in B, by falling, creates a vacuum which the liquid in the wash bottles will fill.

This generator may be made of any desired size, the only thing necessary in large sizes being that the stoppers fit tightly.—*D. F. Farquharson, San Francisco.*

ANALYSIS OF OYSTER SHELLS AND OYSTER SHELL LIME.

By L. P. BROWN and J. S. H. KOINER.

THE sample of shell, retaining the usual small amount of mud, was taken from the dump at a lime kiln near Baltimore, where the burning of the shell is effected in the following manner. It is fed into a conical brick-lined shaft, together with one-tenth of its bulk of dust of either anthracite or bituminous coal, which latter suffices to maintain the combustion. The specimen of lime was taken immediately from the grate of the kiln, and, of course, contains the ash of the coal dust.

Analysis afforded the following, the result for shell being the average of two independent analyses:

	Oyster Shell.	Shell Lime.
CaO	52·14	85·49
CO_2	41·61	0·70
MgO	0·25	0·31
FeO	0·17	....
Fe_2O_3	....	0·33
Al_2O_3	0·08	0·42
Na_2O	0·32	0·69
K_2O	0·03	0·11
SO_3	0·16	0·66
P_2O_5	0·04	0·15
Cl	trace	trace
SiO_2 soluble	0·06	1·14
Insoluble residue	3·24	5·15
Organic matter	2·32	....
Nitrogen	0·14	....
Water	...	3·97
	100·42	99·12

From the former we note that by present prices the shell contains per ton not more than fifty cents' worth of ammonia, which is lost in the burning. This small amount of nitrogen would not warrant the use of any mechanical means of subdivision of the shell, as has been proposed and practiced on a small scale. From the latter analysis we see that shell lime compares favorably in purity with the fair grades of stone lime. *Amer. Chem. Jour.*

LIGHT AND COLOR.*

By Captain W. DE W. ABNEY, C.B., F.R.S.

LECTURE I.

I HOLD in my hand a series of colors of various hues and depths, some of them are fugitive and others are fast colors, and it is the object of the lectures I have been called upon to deliver to answer the questions as to what causes the colors, and what causes the fading of some by light. In four lectures this subject can by no means be treated exhaustively, and I can only endeavor to explain, in as familiar language as I can command, and by some plain experiments, what I desire to enforce upon your minds. A great deal has been written in the last two years on the subject of the fading of water colors, and from what I have gathered from the newspaper correspondence, it is not quite unnecessary that a few familiar discourses on the subject should be given, to prevent a repetition at all events of some of the blunders that have been made in physical phenomena. It may be known to some who are present here to-night that Dr. Russell and myself have carried on a series of experiments during two years on the subject of the fading of water colors, and as our report to the Science and Art Department, which was presented to Parliament, pleases neither the party who cry out that water colors are stable nor yet the party who proclaim the contrary, we may presume that our results are not altogether wrong. To these experiments I shall refer later in the course of lectures.

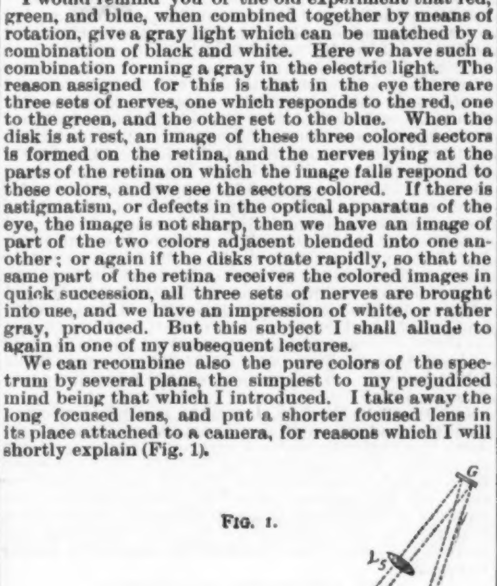
Now, to commence with the elements of color from the physicist's point of view. I wish to show you that the color of an object depends on the composition of the light falling on it, on the material on which such light falls, and on the eye of the person. The screen which I have here is what we call white, when viewed by ordinary daylight or artificial light, and such a screen not only will reflect white light, but also all colored lights with the greatest brilliancy possible.

Let me throw a spectrum on the screen to serve as a text. If a brilliant spectrum be looked at, we see that it is really divided into three colors, blue, green, and red, with shades of other colors blending these colors into one another. I am not going into the theory of the matter, but I would ask you to remember that the mean red light has a wave length of about 38,000 to the inch, the waves being in the luminiferous ether of whose existence we only know by circumstantial evidence, the green of about 50,000 to the inch, and the violet of about 64,000 to the inch. The other colors have intermediate wave lengths.

I would remind you of the old experiment that red, green, and blue, when combined together by means of rotation, give a gray light which can be matched by a combination of black and white. Here we have such a combination forming a gray in the electric light. The reason assigned for this is that in the eye there are three sets of nerves, one which responds to the red, one to the green, and the other set to the blue. When the disk is at rest, an image of these three colored sectors is formed on the retina, and the nerves lying at the parts of the retina on which the image falls respond to these colors, and we see the sectors colored. If there is astigmatism, or defects in the optical apparatus of the eye, the image is not sharp, then we have an image of part of the two colors adjacent blended into one another; or again if the disks rotate rapidly, so that the same part of the retina receives the colored images in quick succession, all three sets of nerves are brought into use, and we have an impression of white, or rather gray, produced. But this subject I shall allude to again in one of my subsequent lectures.

We can recombine also the pure colors of the spectrum by several plans, the simplest to my prejudiced mind being that which I introduced. I take away the long focused lens, and put a shorter focused lens in its place attached to a camera, for reasons which I will shortly explain (Fig. 1).

FIG. 1.



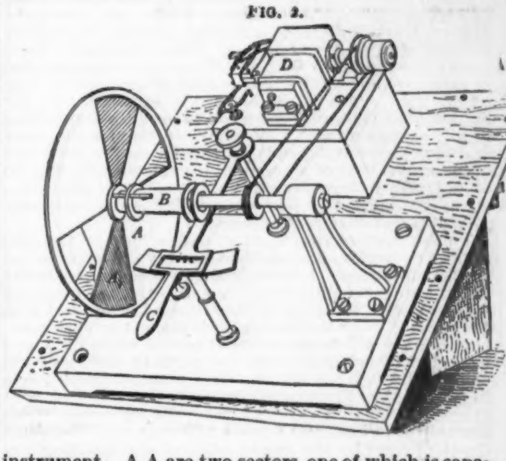
On a collimator, G, to which is attached the usual slit, is thrown, by means of a condensing lens, a beam of light, which emanates from the intensely white-hot carbon positive pole of the electric light. The collimating lens, L_2, is filled by this beam, and the rays issue parallel to one another and fall on the prisms, P_1 and P_2, which disperses them. The dispersed beam falls on an ordinary camera lens, L_3, of slightly larger diameter than the height of the prisms, and a spectrum is formed on the focusing screen, D, of a camera. When the focusing screen is withdrawn, the rays would form a confused patch of pink-colored light on a white screen, F, placed some four feet off the camera. The rays, however, can be collected by a lens, L_4, of about two feet focus, placed near the position of the focusing screen, and slightly askew. This forms an image on the screen of the near surface of the last prism, P_2; and if correctly adjusted, the patch of light should be pure and without any fringes of color. The card, D, is a strip which fits into the aperture left for the focusing screen in the camera. In it will be seen a slit, S_2, the utility of which will be explained later on.

It often happens that a second patch of white light, comparable to that formed, is required. Advantage is taken of the fact that from the first surface of the first prism, P_1, a certain amount of light is reflected. Placing a lens, L_5, in the path of this reflected beam, and a mirror, G, another square patch of light can be thrown on the same screen as that on which the first is thrown, and this second patch may be made of the same size as the first patch if the lens, K, be of suitable focus, and it can be superposed over the first patch if required.

We have now a square white patch upon the screen, from the recombination of the spectrum. If I wish to diminish the brightness of this patch, there are at least two ways in which I can accomplish it. First, by closing the slit of the collimator, and, second, by the introduction of rotating sectors, M, which can be opened and closed at pleasure during rotation in the path of the beam.

The annexed figure (Fig. 2) is a bird's eye view of the

FIG. 2.

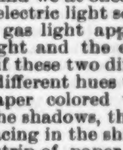


instrument. A A are two sectors, one of which is capable of closing the open aperture by means of a lever arrangement, C, which moves a sleeve in which is fixed a pin working in a screw groove; D is an electro-motor causing the sectors to rotate, and the aperture in the sectors can be opened and closed at pleasure during their revolution. To show you its efficiency, if I place two strips of paper, one black and the other white, on the screen, and cast a shadow from a rod, R, by the direct white light on the white strip, and a shadow from the same rod by the reflected light on the black strip of paper, and interpose the rotating sectors in the path of the reflected light, the aperture of the sectors can be closed till the white paper appears absolutely blacker than the black paper. White thus becomes darker than lamp-black, owing to want of illumination on the former.

We all talk about white light; we say that the electric light is white and that gas light is white. I wish to show you that the whiteness is a mere matter of judgment.

I throw the shadow, by the electric light, of a thick rod on white paper, and another shadow by gas light on the same paper, and we at once see that the shadow illuminated by the electric light seems blue, while that illuminated by the gas light appears orange, yet we speak of both gas light and the electric light as white lights. Evidently, if these two differ so much in color, pigments will take different hues when illuminated by them. Putting paper colored with red, blue, and green pigments in the shadows, the change in hue is at once apparent. Placing in the shadow illuminated by the electric light a strip of paper colored orange (Fig. 3), by orange chrome and aureolin, we see that now the

FIG. 3.



electric light reflected from it appears of very nearly the same hue as the light from the gas reflected from white paper. Gas light we may say, then, is orange rather than white, if we take the electric light as the standard.

We have seen that colors appear of different hue in the electric light to that which they appear in gas light, and I wish to enforce this more strongly upon you by an experiment which I introduced a year ago. In front of the condenser of the electric light lamp I place a circular aperture some inch in diameter, and by means of a lens throw an image of it on a white screen. We may suppose this to represent the sun, the color of the light being very much the same as that which it has in England about midday in the middle of May. In front of the aperture I place a trough containing a solution of hyposulphite of soda, and then drop into it dilute hydrochloric acid, and stirring up the two together, very fine particles of sulphur slowly separate, and the

* Lectures recently delivered before the Society of Arts, London. From the *Journal* of the Society.

white light, owing to the law of scattering by small particles, loses some of its components, and we have a gradual reddening of the sun—first yellow, then orange, and finally a red—the series forming a very exact representation of the colors of a setting sun. If we place colored pigments in this changing light, we see how, toward sunset, the blues become darker, while the reds change but little in hue. It may have been remarked that in an evening the last colors in a picture to disappear are the reds. The color of sunset light now imitated before you gives a clew to the reason of this.

We may as well trace the cause of this change in color. Placing a cell containing hyposulphite of soda in front of the slit of the spectroscope, and throwing the spectrum on the screen, and then adding the dilute hydrochloric acid, we find that as the light from the reflected beam (which we throw just above the spectrum) becomes yellow, orange, and then red, so the spectrum loses the violet, then the blue, then the green, till finally the red alone remains.

Let me further exemplify that you cannot know what effect the color of the light has upon a color unless you know its composition.

The slit, S_1, in the card, D (Fig. 1), can be passed through the spectrum, and as it cuts off all the colors of the spectrum, except that passing through the slit, we have different colored square patches of light thrown by—what I will now call—our patch-forming apparatus, the color of the patch being that of the color issuing through the slit.

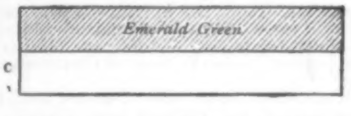
Now, sodium, when ignited, gives a peculiar yellow light, due to a line in the orange. If I send the light from this sodium line through the slit, S_1, we have a square patch of sodium light on the screen. The rod casts a shadow as before, but instead of casting a second shadow by the reflected beam, I cast a shadow from gas light, when it will be seen that the two illuminated shadows have almost the same color.

I shall now perform a common Christmas experiment, and ignite some spirits of wine in which salt has been dissolved, and illuminate with that light cards on which various blue, red, green, and yellow pigments have been placed, and we see that all the pigments partake of various shades of orange, instead of the colors seen by gas light. The reason of this is apparent: in gas light we have all rays present, in the sodium light there is only orange present. We shall see that as the color of a blue pigment depends principally on the reflection of blue rays, that of a green of the green rays, and so on, it is only to be expected that the colors of pigments, when illuminated by pure orange light alone, will only give different shades of orange.

This shows also that light or color may to the eye appear to be the same, and yet be very different in optical composition. I cast two shadows of the rod in the patch-forming apparatus, one by the recombined spectrum and the other by the reflected beam, and pass the card, D, with the slit, S_1, in it along the spectrum. One shadow will be illuminated by the white light and the other by the light from the parts of the spectrum coming through the slit, S_1. If I place emerald green in the shadow illuminated by white light, I find that there is one point in the green of the spectrum which matches it in hue, and I can make them of the same depth of color by the introduction of the rotating sectors. Evidently, then, the colored light of this part of the spectrum and that of the emerald green might be mistaken for one another, and so with other colors. There are some pigments, however, which cannot be matched by the spectrum colors.

That emerald green is a combination of colors I will at once show you. A strip of card is placed in the spectrum, on one-half of which is this pigment. Half of

FIG. 4.



the breadth of the spectrum falls on the white card and half on the pigmented card. It will be seen that the emerald green reflects other colors of the spectrum besides that which it matched in the color-patch-forming apparatus. The combination of all these other colors in the proportions reflected from the pigment forms the color which, in the simple color of the spectrum, we should call emerald green. So, if we pass other pigments through the spectrum, we get similar results, though not all pigments can be so matched.

(To be continued.)

THE BEETLE, ZOPHERUS MEXICANUS, SOL., CUTTING METAL.*

By F. W. DEVOE.

THE beetle to which your attention is directed is *Zopherus Mexicanus*, Sol., a native of Central America, where it is popularly known as "makeche." Specimens average in length from 4·5 to 5 centimeters, and in width from 1·5 to 2 centimeters. [Say 1¾ in. long and ⅝ in. wide.] The thorax and elytra are yellowish gray, this color being due to a coating of scales, which may be scraped away, when the underlying normal black color will appear. The dorsal surface is marked by many knobs arranged in lines, and more prominent in the middle than at the sides. The general color of the under surface and of the legs is black, but this is more or less concealed in numerous places by the yellowish scales before mentioned. The head is retracted as far as the eyes into the pro-thorax. The antennæ are nine to eleven jointed, the outer two or three joints being connate, and, when at rest, the antennæ lie in two deep grooves on the under surface of the pro-thorax.

The character is indicated by the structure. A slow, deliberate walker—it never flies, for its hind wings are not developed, and it never hurries. A lover of darkness—it dwells in the woods, hidden under the bark of trees, in canes, or in chips left by the wood cutter. Strong-jawed, it goes its way.

Much has been said regarding the strength of insects, and especially of beetles. It has been asserted that they have made their way through sheet lead (*Hylotrupes*), and even through iron pipes. Fortunately I have been able to watch this beetle while engaged as a metal worker, and to learn something of its powers.

My first specimen was from Yucatan, presented to me last summer by a friend from Mexico. It was contained in a cardboard box, which I inclosed in my desk overnight. The next morning I found the creature had eaten a large hole in the side of the box, and was enjoying its liberty with a commingling of deliberation and satisfaction. Having recaptured it, I placed it in a small glass jar to which I fitted a cover of wood, after boring a few holes in the latter for ventilation. The next day I found on the bottom of the jar numbers of chips of the black walnut wood of the cover. I then substituted the metal cover which belonged to the jar, after punching through the metal several holes, about three-eighths of an inch in diameter, and supplied the captive with some sugar.

About one week after this I left home for a day, and, when I returned, I found that the beetle had cut out in small bits all the metal between two holes in the cover, and through this enlargement had thrust out its pro-thorax, in such manner as to give evidence that if left alone it would soon regain its liberty. This work upon the metal was all done within the space of forty-eight hours. Upon examination, the cutting edges of the mandibles appeared to be unbroken and in perfect condition. About three weeks after this time this beetle died.

Several attempts were made during the winter to secure some more living beetles of the same species. But they all died before reaching New York. About a month since, however, I had the good fortune to receive two lively specimens. These were placed in glass jars, like that just mentioned, fitted with their respective metal covers.

One of these beetles I exhibit here alive to-night. This one has accomplished metal working precisely like that of the first specimen, and I have had no little satisfaction in watching the process and in listening to the sound caused by the mandibles while cutting the chips from the cover. During this operation the beetle passed the feet through the ventilating holes, and hung suspended, back downward, from the under surface of the cover. This metal is pewter, probably composed of three parts of lead and one part of tin, and is about one thirty-second of an inch in thickness. Under experiment it was found that a force of 369 grammes was necessary to remove chips corresponding to those cut by the beetle. Your attention is called to the fact that the cutting edges of the mandibles of the dead beetle are in good condition, while those of the living beetle are badly broken. Both insects did the same kind of work, under the same circumstances; but I am unable to account for the different effects upon the tools they employed.—*Jour. N. Y. Microscopical Society.*

* Read May 4, 1888, before the New York Microscopical Society.

THE AGE OF THE EARTH.*

ONE of the most interesting problems for persons who devote themselves to the study of geology is this: Can we estimate, at least approximately, the age of the globe, we mean the time that has elapsed since the formation of the terrestrial nebula up to our day? A number of physicists and geologists have undertaken this task, but the discordance in the results obtained plainly says that the methods employed offered no certainty. The majority have found improbable figures—these being hundreds of millions and sometimes thousands of millions of years. The most moderate of these calculations, due to Sir William Thomson, is one hundred million years—a number that appears to us still too exaggerated. The causes of this disagreement and want of success must, we think, be attributed to our ignorance as to the numerical value of the coefficients which enter the putting of the problem into equation when we approach it squarely. Such are the temperature and volume possessed in the beginning by the terrestrial nebula, its density, its degree of heat conductivity, the thermic state of space at that epoch, etc. As direct methods have given negative results only, or at least very doubtful ones, let us have recourse to indirect methods. Until better ones are offered, we propose the following.

Let us say, in the first place, that, instead of calculating the age of the earth in a lump, as has hitherto been done, it is better to divide it up and calculate each part separately. The journey of the earth through space and time, in fact, comprises three distinct stadia, which we shall call the igneous or nebulo-stellar stadium, the stadium of solar illumination or of life, and the stadium of darkness, cold, and death. We shall pass these successively in review and indicate the characters proper to each.

THE NEBULO-STELLAR STADIUM.

This began at the moment at which the terrestrial nebula detached itself from the solar, and ended in the formation of the crystalline crust of the globe. This stadium, the shortest of the three, has, as its characteristic, the transformation of the igneous star into an extinguished one, we mean planet, in consequence of the incrusting of the surface. This hardening was a natural consequence of the gradual lowering of the temperature caused by the radiation of the terrestrial nebula in space. It is possible, we believe, to estimate the duration of this stadium approximately by the aid of considerations drawn from solar radiation.

As one square foot of the terrestrial surface receives, according to physicists, four one-hundredths of a heat unit per second from the photosphere, we find by calculation that the solar mass annually loses, in consequence of its radiation in space, one heat unit per pound. From this we conclude that the great luminary will be extinguished in a dozen million years. On another hand, thermo dynamics teaches us that the photosphere already counts an existence of a dozen million years, and this carries the total cycle of solar radiation up to about twenty-five million years.

As the earth, in mass and volume, is incomparably less than the star of day, it has necessarily cooled much more quickly. We think we shall remain within the bounds of truth in estimating the duration of its cooling at a hundredth part of that of the sun, say 250,000 years. Let us double this figure to take into account the nebular phase which preceded the stellar one, and we find about half a million years as the duration of the first stadium traversed by the earth in its evolution through the ages.

THE STADIUM OF LIGHT AND LIFE.

The second stadium, which comprises the present epoch, and will continue for a long time to come, will embrace the entire cycle of geological formations.

It begins with the Cambrian, and will end at the extinction of the sun, when the cold, congealing the last seas, stops the formation of oceanic vapor, and, consequently, sedimentary action. Its distinctive feature is the advent of the organic kingdom, which marks the adult age of the planet. Like the preceding stadium, it has cooling for its agent.

This great factor of celestial mechanics, which we find everywhere, will serve as a guide and clew for ascertaining the events that will signalize the end of this period.

The most important will be the retreat of the seas, which will profoundly modify the relief of the terrestrial surface. This retreat, due to the infiltration of water into the earth in measure as the latter cools, will give the globe the physiognomy of Mars. As that planet is more distant from the sun than ours, and of less size, it has cooled more quickly. Consequently, the infiltration of the liquid element has been more rapid than with us.

So upon the disk of Mars we observe only small Mediterraneans that occupy no more than about a half of the planet's surface, while the ocean still covers three-quarters of our globe. The water will continue to retire until the day when the cold due to the extinction of the photosphere will congeal our last seas.

The consequence of this recoil will be a gradual increase of the islands and continents, an evaporation of the more and more limited maritime basins, less and less abundant atmospheric precipitations, an increasing sterility of the earth, and, finally, the decline and death of plants and animals.

Thus, deprived of all life, the earth will no longer be anything but an inert mass, lost in space.

The duration of the stadium just described may, we think, be calculated by the aid of two methods, each of which controls the other. According to the estimates of geologists who have measured in various parts of the globe the thickness of the sedimentary deposits, we may fix the total thickness of the same at about sixteen miles. If we know the time that has elapsed during the formation of a stratum 1,000 ft. thick, a simple multiplication will allow us to find the age of the sedimentary crust of the globe. If the calculations that we have already given * on the subject of the periodicity of great circumpolar winters are exact, we can fix the duration of the quaternary epoch at about seventy thousand years. The mean thickness of the quaternary formation being estimated at 650 feet, we conclude therefrom that it will take three hundred and fifty thousand years to produce a stratum about half a mile in thickness, and this carries the duration of the sedimentary stadium traversed up to our day to thirteen million three hundred thousand years.

This figure should be increased a little, since, the stratification of the deposits having in the course of ages been interrupted here and there, in consequence of the oscillations of the earth, a number of layers have not been deposited upon the subjacent formations until after a lapse of time difficult to estimate precisely. We do not think that we get far away from the truth in estimating the addition that it is proper to make at about two millions, which would raise the duration of the organic stadium traversed up to the present to fifteen million three hundred thousand years. Such is the result given by the first method. The second rests upon observations drawn from the eye of the trilobite.

This crustacean, as we know, inaugurates the paleozoic age, for it is found in the upper strata of the Cambrian. The mode of structure of the visual organ indicates that the latter was formed under the influence of a light that was more intense than that of our day.

Hence we conclude that the photosphere of the sun was at that epoch formed, and had as yet lost nothing of its energy. We have said that, according to the calculations of thermodynamics, it has already existed a dozen million years (a figure that agrees pretty well with the one that the preceding method gave us), and that the career that remains to it to finish is estimated at two-thirds of this figure, say a total of twenty-five million years. Such will be the cycle of the organic stadium.

THE STADIUM OF DARKNESS, COLD, AND DEATH.

The third and last stadium will have for a starting point the end of solar illumination, of sedimentation, and of the living world, and will terminate in a terrible catastrophe—the fall of the earth upon the extinguished globe of the sun. A new era, that of darkness, cold, silence, and death, will open for our planet.

Our abode will no longer be anything but a frozen tomb, circulating noiselessly around another tomb likewise frozen—the extinct sun.

An extraordinary, but not unforeseen, event will interrupt the monotony of this silent travel and will, for a few seconds, render heat and light to the dark globe; we mean the fearful cataclysm caused by the fall of our globe. Here we change guiding thread and leave aside the cooling, which has nothing more to give us, and substitute for it another factor of celestial mechanics—gravitation.

The secular accumulation of the lunar motion has for a long time been demonstrated, and astronomers of the last century justly occupied themselves with this frightful eventuality. It results, in fact, from Kepler's third law that a star which accelerates its travel shortens its orbit at the same time, so that, in the long run, it is sure to fall upon the body around which it gravitates.

Such is the case of the moon with respect to the earth. Laplace reassured his contemporaries for an instant by demonstrating through mathematical analysis that the motion of our satellite is connected with variations in the eccentricity of the terrestrial orbit, and that the present accumulation will stop some day in order to become retrograde.

But the calculations of the great geometrician render account of but half the value of this motion. A profounder study of the gearing of the cosmical machine has revealed the existence of a new agent that was unknown in Laplace's time. We mean the one hundred

* Adolphe d'Assier, in *Revue Scientifique.*

* See SUPPLEMENT, Nos. 631 and 632.

and forty or one hundred and fifty thousand millions of meteorites that annually traverse our atmosphere and cover the earth with their debris.

We pass in silence those captured by the moon, although their number is not to be disregarded. However small these corpuscles be supposed, their dust, continuously falling upon the two stars, will eventually, in the course of ages, perceptibly increase their mass. According to the great Newtonian law, we know that two bodies attract each other in direct ratio of their masses, and in inverse ratio of the square of the distances that separate them.

The planet and satellite will therefore move toward each other until they join. The smaller of the two globes will be crushed in clashing against the larger, the latter will return to incandescence through the conversion of the lost motion into heat, and the astronomers of neighboring planets will see a new star shining in the sky. The light will last but a few days or few weeks, and darkness, resuming its sway, will soon prevail over the transitory illumination. Starting from this moment, the globe will resume its silent course through space, having gained by the catastrophe but an insignificent increase in mass and volume. How will it end its career? Here we shall appeal to celestial mechanics, and the law of gravitation will give us the key to the enigma. As the earth, with respect to the sun, is what the moon is with respect to the earth, the course of the latter is naturally moulded after that of the satellite, and will end in the same catastrophe. If we reckon the meteorites that annually fall into the terrestrial atmosphere to number thousands of millions, it is by myriads of thousands of millions that it is necessary to number those that are engulfed in the solar atmosphere. The two stars are approaching each other, then (in an imperceptible manner, it is true, since it has hitherto escaped the attention of astronomers, but appreciable in the course of ages), as the continuous fall of corpuscles is increasing their mass, and consequently their attractive force. Hence the collision is certain.

The earth will end its career by becoming crushed like a meteor on the surface of the extinct sun, which the violence of the impact will restore to incandescence for a few instants. The last act of the tellurian drama will be the appearance of a temporary star in the firmament. In the present state of our knowledge, it would be puerile to try to estimate the duration of the stadium that has just been described and that may be defined, as we have said, the age of darkness or eternal night, of cold and of death.

Such a calculation cannot be undertaken until the day when we know precisely the secular acceleration of the motion of the earth around its focus of attraction. All that it is permitted us to advance is that, according to every probability, the duration of this stadium will be much longer than that of the preceding, and we think that we can, at the lowest, estimate it at one hundred million years, perhaps more.

Upon the whole, the present age of the earth appears to be about sixteen million years. This is but a small part of its existence, and everything leads to the belief that its total evolution through the immensity of space will exceed a million of centuries.

[FROM THE AMERICAN NATURALIST.]

SKETCHES OF THE CASCADE MOUNTAINS OF OREGON.

By E. D. COPE.

THE Cascade Mountains of Oregon are destined to be the favorite resort of tourists who love all that is most beautiful, impressive, and wild in mountain scenery. Lying over one of the greatest of the fractures of the earth's crust, they represent the remains of successive outflows of molten material at its source. The basis of the range is eruptive, and displays the irregularities of surface due to such origin within comparatively recent geological ages, and to the rapid erosion which naturally occurs in a humid climate. Thus gorges of great depth traverse its masses, and precipices of tremendous height bound many of its elevations. Beautiful lakes nestle in its depressions, and waterfalls leap from level to level on their way to the tributaries of the Columbia. All is clothed in somber forest of conifers, of larger proportions or more elegant foliage than can be found in any other range. High above all these mountains tower at intervals along the range the great snow-peaks which give the region its especial beauty. These are extinct volcanoes which raised themselves round vents which long remained open, and which poured out lava, scoriæ, pumice, and ashes, after the great fissure was closed.

The great lava outflow from the Cascade Mountain fissure is one of the most extensive the world has ever seen, and was one of the most destructive in its consequences. There were several distinct periods of outflow, two being especially distinguishable in the stratigraphy of central Oregon. Between the outflows from this and from lesser sources to the eastward, a country of eight hundred miles in east and west extent, and one hundred and fifty miles from north to south, was covered with lava and other ejectamenta, rendering it uninhabitable by animal life. The volcanic materials are found for several hundred miles to the north, at some points continuously with the great tract I have mentioned. The exact connection with the latter remains to be ascertained; but both were deposited at about the same geological period, viz., from some time in the Eocene to late in the Miocene ages. The area covered is not less than 1,600,000 square miles in extent, embracing all of central and southern Oregon and southern Idaho, and large tracts in Tacoma Territory. As an offset to this terrible and unexampled desolation of one of the fairest parts of the earth's surface, we have the great snow-peaks standing as silent and imperishable monuments of one of the most tremendous of the wars of the elements that the later earth has experienced.

The grand tour of Oregon is commenced by crossing the gap in the Cascade range at Ashland, just north of the California border, and visiting the Klamath Lake on the eastern side of the watershed. Turning northward, the tourist should visit the Crater Lake, twenty-five miles from Fort Klamath, and return. Then go northward again on the edge of the plateau that overlooks the valley of the Des Chutes River toward the west, from which the highest of the ranges of the Cascades rise, and may be seen in all their magnificence. Continuing on this road, now a stage route, the Dalles of the Columbia River are reached. Thence take the steamer down the river for Portland. The scenery of the long pass of the Columbia through the Cascade Mountains has been often praised, but never too highly. From Portland excellent means of transportation south, up the Willamette valley, will return the traveler to Ashland again, and the grand tour is completed. A trip from Portland to the resorts on the coast range must not be omitted, for from these can be seen, it is said, twenty of the snow-capped summits of Oregon and Tacoma (Washington), on the one side, and the boundless waters of the Pacific Ocean on the other.

The traveler must make this journey in a private conveyance, if he can do so, excepting as to the Columbia River. He should commence at Sisson's at Mount Shasta, in northern California. Then he will see the mountains in all their changing moods at his leisure. He will become personally acquainted with each of the great landmarks as he passes them one by one. First, Shasta of colossal dimensions. Then the perfectly regular Mount Pitt, which overlooks Lake Klamath. Then the Batchelor, with blunt apex; next Mount Cope, with its dome and its lower twin summit; and twenty miles to the north, the two peaks of Mount Condon, joined at their bases, acute and inaccessible. At a longer interval follows Mount Jefferson, which rears its immense bell-shaped mass from a widely spreading base to a height of 13,000 ft. Finally, near the Columbia, the perfect cone of Mount Hood lifts its head 14,000 ft. and more to the skies. The form of all the peaks is essentially Andean. They are, like Popocatapetl, Cotopaxi, and Pinchincha, of a general conical form, and thus quite different from the mountains of the Rocky range, or the Alps, which are mostly culminations of larger masses, or rise from plateaus, so that the visual effect of their elevation above the sea is largely lost. The case is different with ranges whose base is, like that of the Cascades, but little elevated above the sea. In the latter nearly the entire elevation is visible. The Cascades also, gathering the moisture from the ocean in a northern latitude, receive and display a greater deposit of snow than ranges of greater elevation in drier or more southern regions.

Although there are many lovely lakes in the Cascade Mountains, none is so remarkable as Crater Lake. This is a body of water which occupies an extinct crater of large size. It is of an oval form and about eight miles by six in diameter. The walls which surround the water rise to a height varying from 900 to 3,000 ft., and they are so precipitous that their descent is practicable at very few points. At the time of my visit (in 1879) but one mode of access to the water was known to my guides. This I descended to the water's edge. It is a very steep washed slope covered with loose stones and scoriæ, among which the descent is much more easy than the ascent. To the south of the center of the lake is an island which consists principally of a volcanic cone, with a distinct crater in its summit. This represents the latest center of activity of the volcano. Its sides were covered with tall firs at the time of my visit. The depth of the water is very great. Captain C. E. Dutton, of the present U. S. Geological Survey,

VIEW FROM LAKE KLAMATH, LOOKING NORTH TOWARD CRATER LAKE.

informed me that he obtained 1,900 feet as the greatest depth, and 1,500 as the average, in 1886. (See plates.)

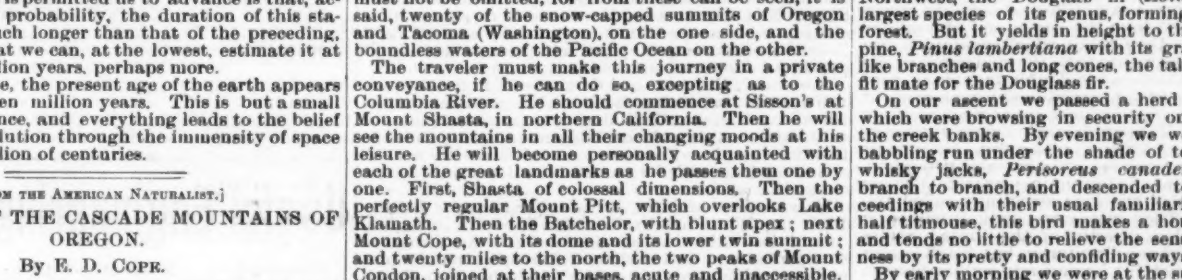
At the time of my visit Colonel Whipple was in command at Forth Klamath. He carried out a projected visit to Crater Lake at this time, and kindly gave me the opportunity to accompany him. As we left the post we were greeted by the clamor of the beautiful white-headed woodpeckers (*Picus albolarvatus* Cassin) which nested in the tall pines near the officers' quarters. We soon passed Seven-mile Creek, which abounds in the red spotted trout of the Pacific coast, or the "dolly varden" (*Salvelinus malma*), and commenced the ascent. We followed the course of a mountain torrent which often disclosed in its precipitous banks the friable volcanic material of which the mountain is composed. Sand and ashes, with here and there strata of fragments of scoriæ and lava, were principally visible. The soil was evidently good, for it supported a luxuriant forest of trees and undergrowth. Prominent among the former are two beautiful firs, whose foliage is elegant but broadly contrasted in character and appearance. These are the *Abies nobilis* and the *A. pattoniana*. The foliage of the former is rigid, and the disposition of the terminal branches almost rectangular. The green is of a rather dark shade. The second species is, on the other hand, feathery in foliage and gracefully drooping in branches, and the green is paler.

Above both these species towers the monarch of the Northwest, the Douglass fir (*Abies douglassii*), the largest species of its genus, forming the bulk of the forest. But it yields in height to the occasional sugar pine, *Pinus lambertiana* with its graceful candelabra-like branches and long cones, the tallest of pines and a fit mate for the Douglass fir.

On our ascent we passed a herd of blacktail deer, which were browsing in security on an open slope of the creek banks. By evening we were encamped on a babbling run under the shade of towering firs. The whisky jacks, *Perisoreus canadensis*, flitted from branch to branch, and descended to inspect our proceedings with their usual familiarity. Half jay and half titmouse, this bird makes a home of every camp, and tends no little to relieve the sense of savage wildness by its pretty and confiding ways.

By early morning we were at the summit. This was simply an open grassy expanse on the eastern edge of the awful chasm, surrounded by an irregular border of the forest. The day was clear, and everything could be seen in perfection. Far down on the water I descried a moving white speck, probably a trumpeter swan, as no smaller bird would have been visible at the distance.

Across the gulf rose the two points of the mountain called by the hunters the "Rabbit's Ears;" and further to the northwest the aiguille known as "Cowhorn Peak." The water of the lake glistened in the sun, oblivious to the awful scenes that had once rendered



this place the pandemonium of the continent. I descended to the water's edge, and examined carefully for traces of animal life. I found a very young larva of a salamander. More fully grown specimens have been since obtained by Lieutenant Carpenter, U. S. Army, and sent to the National Museum, which are probably the young of *Amblystoma macrodactylum*, the only salamander that has been found adult in that region. Then I found larvæ of Phryganeidæ and Ephemeridæ, and some minute crustacea, as Gammari and water fleas. Among the rocks on and beside the slope, the "little chief" hare, *Lagomys princeps*, crept in and out, uttering the while its peculiar plaintive cry. It is a rather tame animal, and apparently possessed of much curiosity, but it has always a fissure in the rock at hand into which it retreats if one approaches too near.

The walls of the crater on the eastern side are made up of successive layers of lava, scoriæ, sand, ashes, pumice, etc., all representing successive eruptions and parts of eruptions. The mass is in places friable, and is penetrated by the waters of the lake at different points, thus giving origin to springs and streams.

At Fort Klamath the soil rests on a deep stratum of pumice. Some of the exposures show this to be broken up and water-worn, but at other places it forms a continuous spongy mass. In a stratum of this kind, just below the soil, were cut the four graves of the Modoc Indians who were hanged for the assassination of General Canby, the commissioner sent by the United States to treat with the tribe. These graves were cut out with right angles and borders by the simple use of a sharp spade. At the time of my visit all of them had been rifled, and the bodies taken away. I afterward obtained the skeleton of one of them. It is characterized by a platycnemic tibia and trituberculer second and third superior molars.

Soon after this visit I left Fort Klamath for a geological exploration of the Oregon desert. Of this I may have something to say at another time. I found unexpected assistance in this exploration through Mr. Charles Whittaker, son of the governor of the State, who kindly placed his time and conveyance at my disposal, and accompanied me to Fossil Lake and the sandy region beyond. We returned *via* Silver Lake, and took the main road for the Dalles. This road runs north along the western edge of the sagebrush and the eastern border of the valley of the Des Chutes River. There is nothing to obstruct the view of the Cascade range from this road, and as the greatest elevation of the range is at its eastern border, the view of it from this road is the finest that can be obtained. At a point twenty to twenty-five miles south of Prineville, nearly half the length of the Oregonian portion of the range is included in the panorama, at a least distance of seventy-five miles. From the line of forest-covered mountains rise five magnificent snow-peaks to heights varying from 10,000 to nearly 15,000 feet above sea level. To the north is Hood, then succeeds Jefferson, then Condon, Cope, and the Batchelor. As these mountains do not rise from a plateau as do those of Colorado, the effect they produce is more impressive than that of mountains of greater elevation in the latter region. The wedge of Hood and the cone of Jefferson only find their counterparts in the celebrated volcanoes of the Cordilleras, whose praises have been often celebrated; but nowhere can five Cotopaxis be seen at one view, but in the Cascades of Oregon. They are ideal mountains, grandly simple, whose outlines, rising from base to summit, are only interrupted by vast precipices. They pierce the blue sky with a vertical mile and more of purest white "as no fuller can white," save where the crags are too steep for the snow to cling. When I first saw Mount Hood, nothing but its cone was visible, an island of light floating in a sea of clouds. When I saw it last, clouds had again separated its summit from the earth, and the rays of the sun gave it an *Alpenglühn* which resembled the red glow of a furnace rather than the cold sheen of the ice peak. Mount Condon is a double mountain, consisting of two peaks with sharp summits connected by a high saddleback. Its outlines are as steep as those of the others, and it presents an immense surface of snow. Mount Cope is twenty miles south. Its summit is an obtuse cone surrounded by impassable precipices. It is next to Mount Jefferson in elevation. These mountains are two of the four sometimes called the "Three Sisters." They were given distinct names by the late Dr. Hayden, director of the United States Geological Survey of the Territories, but his ill health and death prevented his issuing any publication on the subject. Mount Condon was dedicated to Professor Thomas Condon, of the University of Oregon, a distinguished teacher of geology and the discoverer of the Miocene beds of the John Day River, of Oregon, which have produced so many remarkable vertebrate fossil remains. The Batchelor has an obtuse apex and resembles somewhat Mount Etna in its outline. A general view of these mountains is given in the accompanying sketches, which I took from two of our camps. One of the last views I gained of the snow peaks was in the morning as the sun rose. The valley of the Des Chutes was, as before described, filled with white clouds, and these rose to such an elevation as to conceal all but the summits of the volcanic cones. As the sun's rays rested on them they all glowed with such intensity that they could be well compared to masses of red hot iron suspended in the heavens, and by a stretch of imagination be conceived as once more in their hoary age, ablaze with their internal fires, attempting to revive the terrible glories of the past.

Our road took us away from these sublime scenes of the upper world to equally extraordinary if not as gigantic exhibitions of the ancient activity of the volcanoes in the bowels of the earth. We descended into the canyon of the Des Chutes and followed its course for many miles. The descent could not have been less than 2,000 feet, and was accomplished by zigzags and stages innumerable. Prof. Newberry has described this canyon in his report in the series of the United States Pacific R. R. Survey volumes. Its walls display a remarkable section of the materials which the eruptive forces cast far and wide, or forced to flow over this afflicted country. High upon the walls of the canyon is a horizontal layer of columnar basalt, the columns vertical. Below this, separated by many feet of a friable deposit, is a stratum of well defined, apparently sedimentary, rock. A deep bed of ash is followed below by another bed of columnar basalt, and this again, after an immediate soft stratum, by a third bed. In the two lower beds the columns are variously disposed. They are frequently curved, forming concentric arcs, disposed in various directions according to locality. Sometimes the columns are horizontal, resembling piled cord-wood, and all are generally regular and more or less artificial-looking.

From this extraordinary gorge we finally issued on a rolling country well covered with bunch grass, which continued to our destination, the Dalles, on the Columbia River.

HEADACHE FROM EYE STRAIN.

PHYSICIANS have come at the conclusion that headaches are very frequently caused from overstraining of the eyes, that defective vision is more often the source of head troubles than most persons thus affected are aware of themselves. There has come to our knowledge a number of cases where perfect relief has been derived by persons adopting glasses who had not the slightest idea their vision was defective, and the cause of their headache, till the discovery was made by an oculist. Therefore, to persons subject to the kind of headache not arising from acidity of the stomach or over-indulgence of the appetite, we would recommend to have their eyes examined by a skillful oculist, who will discover any defect in the vision which would be likely to produce the head pain, and if so, he will give directions for the manufacture or selection of such glasses as will relieve the eye strain which has produced the suffering.

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